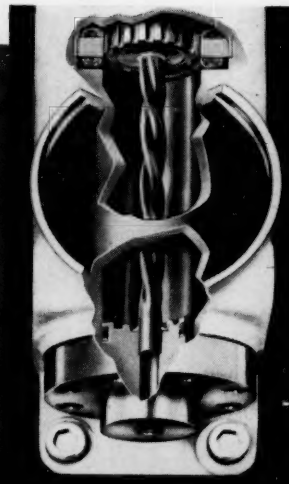
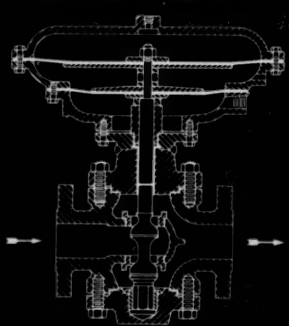
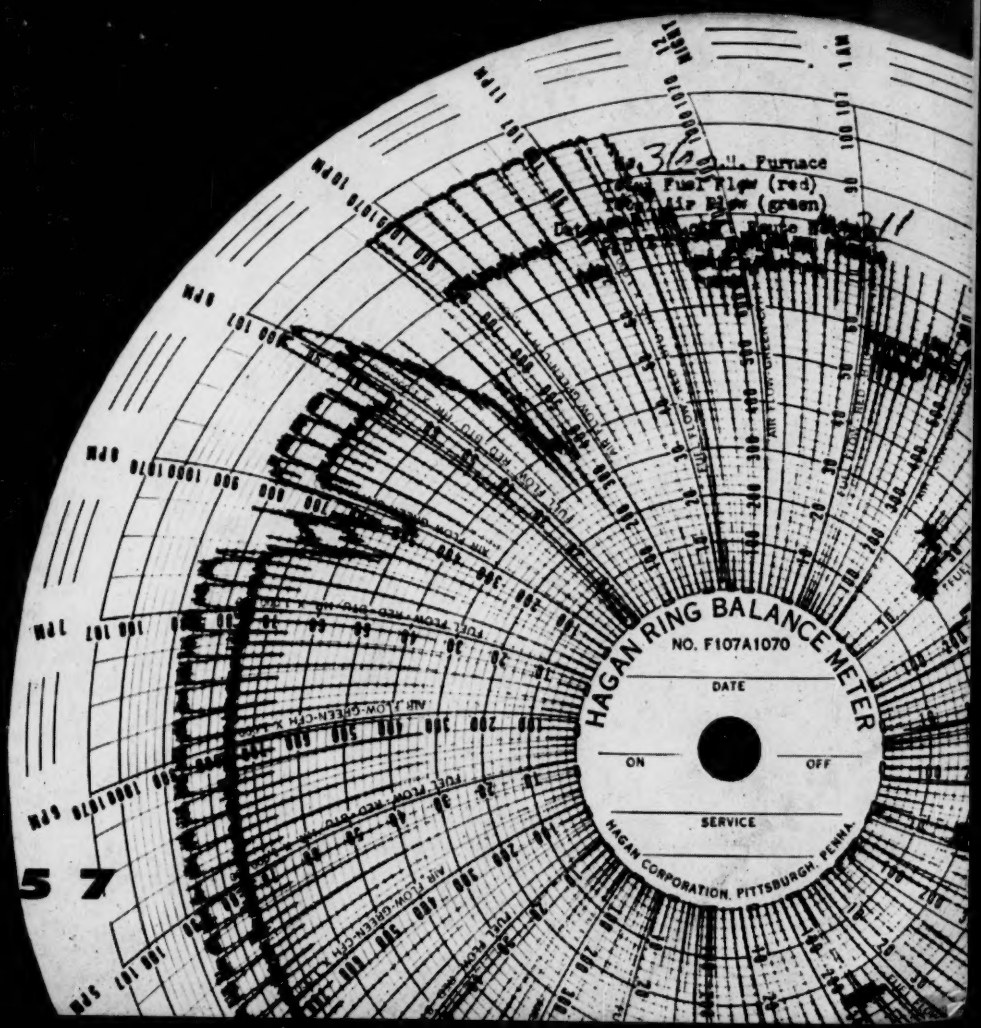
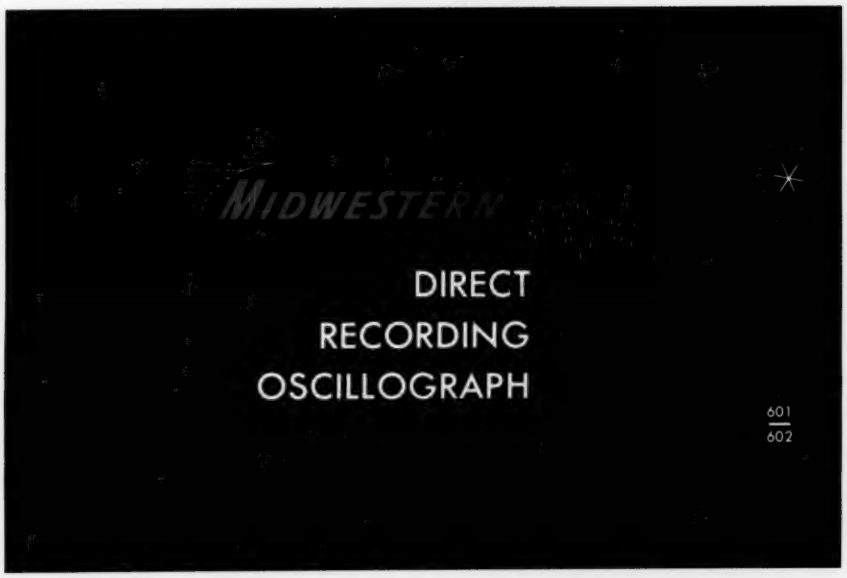
INSTRUMENTS and AUTOMATION

Including: Instrument Manufacturing • Journal of the SCMA • Simulation Council Newsletter









Please turn to page 1232

For more information circle **1** on inquiry card.

positive mechanical drive

for greater accuracy
in graphic data
recording

MODEL 200-A for resistance inputs

Control panel configuration of MODEL 200-B for DC signal input

LIBRASCOPE'S UNIQUE "FLOATING GEAR TRAIN,"
and conservatively rated conventional vacuum tube and harness circuitry result in static accuracy of 0.1% and dynamic accuracy within 0.5% of full scale, at a tracking rate of 5 inches per second.

The Librascope Models 200-A and 200-B XY Plotters are engineered for accuracy, rapid response, and ease of operation. The positive mechanical drive of the Floating Gear Train eliminates lost motion, cable stretching or alignment adjustments, normally found in the cable tape or lead screw type of drive. The new, simplified plotting pen of one-piece design—used for point or continuous plotting—eliminates bottles and tubes—permits rapid changing of ink colors. Easy to load and always visible, the plotting table accepts paper up to 11" x 17". Point plotting or curved tracing is accomplished with equal ease with one-second full scale response. A variety of input accessories are listed below.

MODEL 200-A can utilize any external resistance potentiometer as an input transducer associated with each axis. Independent 10 to 1 scale expansion and origin positioning controls are provided. Facilities for external control of the pen drop solenoid and for simultaneous control of external equipment through switch closures, are provided.

MODEL 200-B, used for DC signal input, has full-scale sensitivities of five millivolts and an input impedance of 1,000 megohms in the millivolt scale ranges. Drift-free operation is assured by chopper-stabilizing the voltage inputs against an Epply standard cell reference.

READILY ADAPTABLE FOR RACK MOUNTING

Librascope XY desk model plotters are readily adaptable for mounting in standard RCA and RMA racks, for which accessory hardware is available at slight extra cost.

LIBRASCOPE PUNCHED CARD CONVERTER

Provides for the conversion of data read from IBM punched cards into analog signals that the MODEL 200-A Plotter can accept as inputs.

LIBRASCOPE PUNCHED TAPE CONVERTER

Converts the digital information read from punched paper tape into electrical signals suitable for the control and actuation of a MODEL 200-A Plotter.

LIBRASCOPE X-Y DECIMAL KEYBOARD

Consists of three-decimal bank for each axis with associated plus minus keys. Features Librascope designed positive-action self-wiping contacts.

LIBRASCOPE BINARY CONVERTER

Translates X and Y coordinate information received in the form of binary signals into analog signals for automatic point plotting by a MODEL 200-A Plotter. Has a capacity of nine binary digits and a resolution of one part in 512.

Career opportunities exist at Librascope for qualified engineers, physicists and mathematicians. Learn about Librascope's new "Creative Project Development Teams." Contact Glenn Seltzer, Employment Manager.

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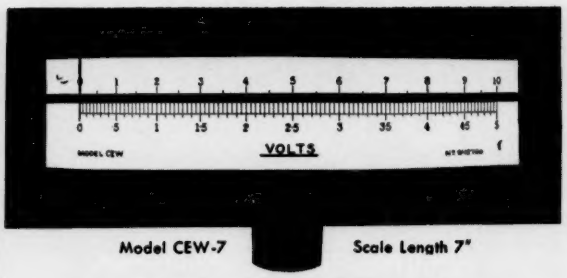

Model CEW-7 Scale Length 7"

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Vertically Mounted and Edgewise Panel Instruments that conform to the most rigid specifications normally reserved for secondary electrical indicating standards in the laboratory. All instruments have Hand Drawn Mirrored Scales. Available with *Diamond Pivots* and *Shock Mounted Jewels.*

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Frequency Instruments
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Current Product Instruments
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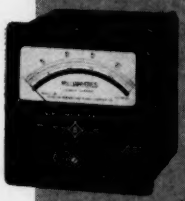
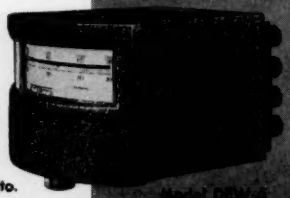
Model JW-4
Scale Length 4"
Accuracy .5%



Model UPP
Scale Length 4"
Accuracy .5%



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For more information circle **4** on inquiry card.

INSTRUMENTS and AUTOMATION

EDITED FOR USERS OF MEASUREMENT AND CONTROL INSTRUMENTS

Volume 30, No. 7
July 1957

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Editorial

Management Asks Questions 1283

European Survey Planned 1285

Feature Articles

Solid-State Amplifiers in Control Systems 1288
J. A. Baring

Electronic Commutator 1292
J. F. Davidson

Pressure Regulators for Back-pressure, Flow, Pump Discharge 1293
C. S. Beard

Digital Transducers 1299
Martin F. Klein, Frank K. Williams, Harry C. Morgan

Flexure Sine Bar 1301
Al Cline

Eni, Meni, Mini, Moni—ACS 1302
Nelson M. Blachman

Electronic Circuitry 1304
Charles F. Kezer and Milton H. Aronson

Two-Point Roof Temperature Control of Open-Hearth Furnaces 1312
C. R. Ellstrom

Journal of the Southern California Meter Association

Speed Control of Centrifugal and Reciprocating Compressors 1324
C. G. Laspe

The Simulation Council Newsletter 1317

Other Regular Features

Letters to the Editor	1222	Biographies of Significance	1265
Inquiries	1228	New Instruments	1330
Events	1234	Briefs	1372
Trends	1237	New Literature	1382
Panhandle Pete	1239	Searchlite Section	1392
News	1244	Advertiser's Index	1394
Stock Report	1253	Inquiry Card	1395

THE MAGAZINE OF INSTRUMENTATION AND AUTOMATIC CONTROL SINCE JANUARY 1928

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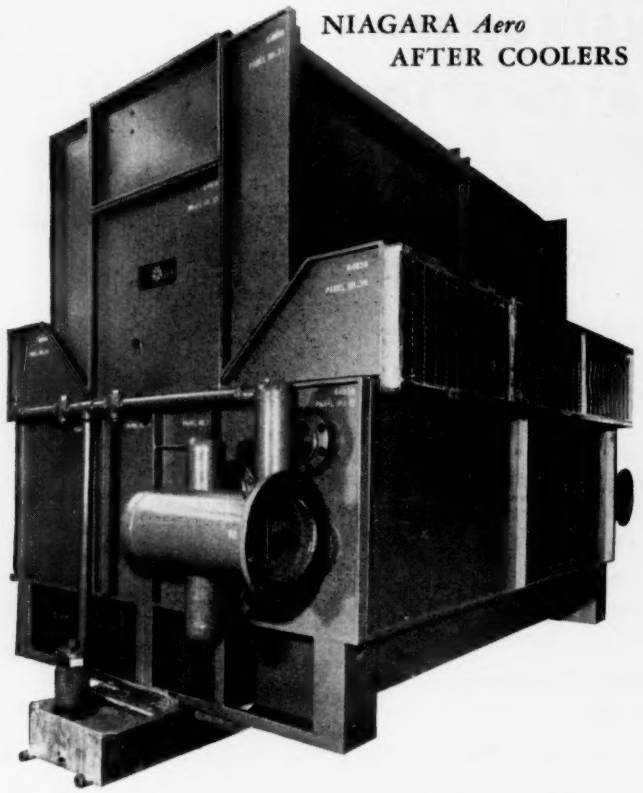
NIAGARA *Aero*
AFTER COOLERS



ECONOMICAL COOLING OF GASES and COMPRESSED AIR

● Cooling gases or cooling and removing moisture from compressed air, the Niagara *Aero* After Cooler offers the most economical and trustworthy method. Cooling by evaporation in a closed system, it brings the gas or compressed air to a point close to the ambient temperature, effectively preventing further condensation of moisture in the air lines. It is a self-contained system, independent of any large supply cooling water, solving the problems of water supply and disposal.

Cooling-water savings and power-cost savings in operation return your equipment costs in less than two years. New sectional design reduces the first cost, saves you much money in freight and installation labor and in the expense of upkeep.

Niagara *Aero* After Cooler systems have proven most successful in large plant power and process installations and in air and gas liquefaction applications.

Write for Descriptive Bulletin 130

NIAGARA BLOWER COMPANY

Dept. IN-7, 405 Lexington Ave. New York 17, N. Y.

District Engineers in Principal Cities of U. S. and Canada

For more information circle **5** on inquiry card.

Letters to the editor

Editor, I&A:

Relative to your editorial in the May issue of *I&A* [Education—A Multi-Level Problem] I wish to take exception to the implication of one paragraph—"But the average college instructor is too often contemptuous of the 'commercial' equipment or advertisement—."

Out of respect to the "average college instructor," I believe that you should print a retraction. The majority of these people do, I am sure, respect the commercial equipment and would like to use it. You may have gotten your impression from the "bread-board" contraptions often seen in college laboratories. I have them, too! But why? Inflation!

Inflation has hit everywhere except the schools' budgets. We should purchase modern equipment to use in connection with Computers, Servos and Controls, which would cost about ten times the *total* new equipment budget for the entire University this year. What do we do? Either we talk about the equipment in general terms and show pictures, or we attempt to make a "mucket" monstrosity which should be its "equivalent"!

And what burns me up still more is that such a large majority of the manufacturers have a good answer when you ask them for an "educational" discount. After you clear away the dross, their answer reduces to "Directly, or indirectly, our equipment is being made for government contracts and we don't need your business." But they want our graduates.

So please give the college instructor the break he deserves (and seldom gets), and don't blame him for not using modern equipment. Put the blame where it belongs!

P. O. Huss
Associate Professor
University of Akron

We certainly do wish to give the college instructor or professor every possible break, but your editors had a slightly different point in mind than the one picked up.

You are entirely correct to point out that today few persons lack respect for real equipments (as implied by the statement)—but it is also true

Pinboards simplify electronic computing... multiply technical talent

A desk-size computer for the instant solution of problems between the scope of desk calculators and costly "electronic brains." Saves priceless hours for engineering personnel. Exclusive pinboard programming — makes the difference . . .

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More E101's are shortening the time between problem and solution than all other comparable electronic computers combined. They can be delivered, installed and put to work immediately. For complete descriptive booklet, or the solution to one of your typical problems, write:

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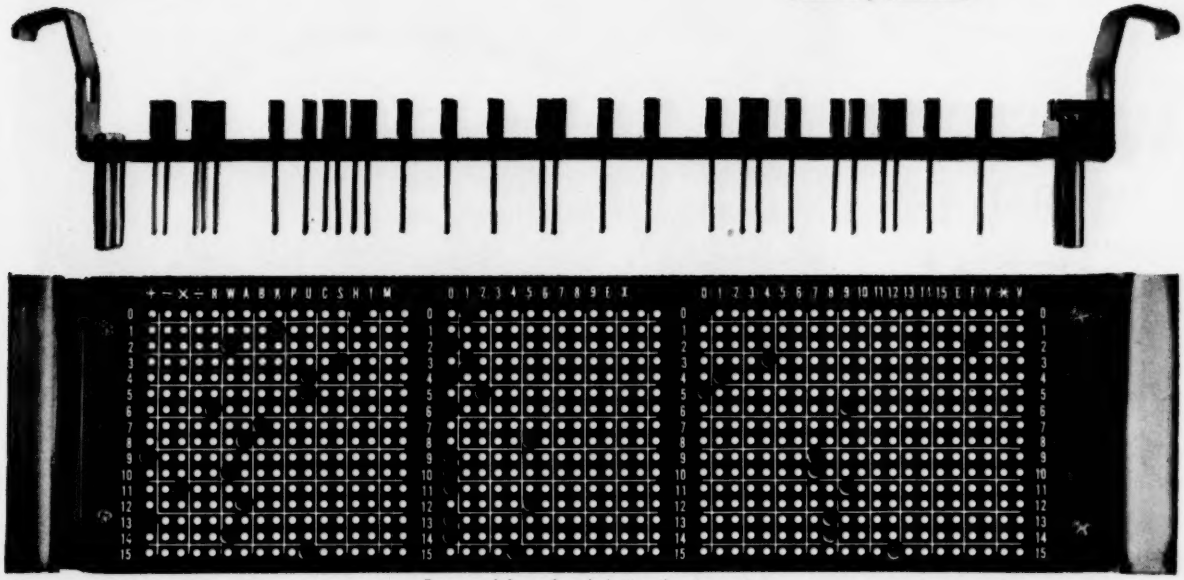


For more information circle 6 on inquiry card.

THE THERMOELEMENT

simply plugs-in

No need returning the Model 622 for thermoelement replacement; nor wiring a new one in. A spare element, or one immediately available for the individual instrument, can be instantly *plugged in*. Replacement units are furnished with correction curves to maintain the guaranteed high accuracy with original scale calibration. This is just one of several exclusive design features which make Model 622 more convenient, more flexible in use. And coupled with its *proved* high accuracy and stability, it remains the outstanding favorite for all high frequency problems. Available as thermo milliammeters and thermo voltmeters; and thermo ammeters, (external thermoelement type). Also as d-c voltmeters, millivoltmeters, milliammeters, microammeters, electrolysis volt-millivoltmeters, and as high accuracy rectifier type a-c instruments. Write for bulletin A20. Weston Electrical Instrument Corp., Newark 12, N.J.

WESTON
MODEL 622
portable
THERMO INSTRUMENTS

For more information circle **7** on inquiry card.

LETTERS—CONTINUED

that their high cost precludes their continuous procurement by teachers. Hence our emphasis should have been on the words "or advertisement."

By implication (which obviously was too weak) we meant to bring out that the university instructor is not using the *second* best way to keep his students abreast of developments—by requiring them to read the monthly trade journals.

For example, each issue of *Instruments and Automation* reports about 200 new products each issue, more than 200 commercially advertised equipments, and analyzes one or two complete classes of instruments in its feature articles. This is the country's (if not the world's) best news and reporting service on commercial equipments—and the articles have high educational value. Yet how many college instructors require their students to read *Instruments and Automation* each month?

Editor, I&A:

We are interested to learn if your publication has ever made a survey on automation as an industry.

Primarily, we are interested in *automatic controls* used in processing and manufacturing operations and whether their manufacture may be considered as a sub-industry group within the framework of electronics. If the manufacture of automatic control equipment can be so classified, has this "industry" ever been the subject of a study either by your organization or some other source?

Richard G. Fourman
Texas Eastern
Transmission Corp.

The Following references will give you a good picture of the industry:

1. A "Historical Museum on Paper" of American Instruments. *Instruments*, January 1948, pages 33-75; February 1948, pages 128-168; March 1948, pages 248-266; April 1948, pages 334-350.
2. Twenty-fifth Anniversary Issue of *Instruments*, January 1953, pages 33-42.
3. A Brief History of the Instruments Publishing Company, *Instruments*, January 1953, pages 43-48.
4. The Instrument Industry—Today and Tomorrow. *Instruments and Automation*, Jan. 1954, pages 114-118.
5. The Instrument Industry—An Economic Report by Richard Rimbach. *Instruments and Automation*, June 1951, pages 1122-1125.

RAMBLINGS ON INSTRUMENTATION

Technological breakthrough ! ! —Highway program moves ahead!

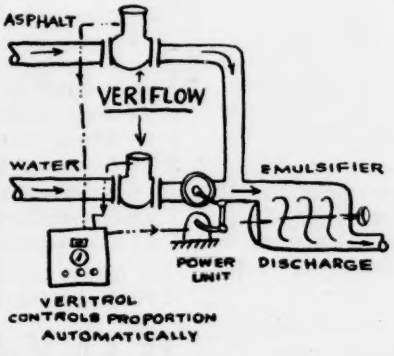
News has just reached this office that American ingenuity has triumphed over the tricky, sticky job of making emulsified asphalt. Since this has earth-shaking significance for all highway loving citizens, we are reporting it forthwith.

The people who make asphalt take extreme care to insure the absolute uniformity of the water-to-asphalt ratio of their product. The ratio varies, but once a formula has been selected, they control it with the scientific zeal of a 5-to-1 martini man.

Riding herd on the asphalt-water ratio used to be a full time job for one man in a small asphalt plant, or several men in the big plants. With experienced labor high-priced and hard to come by, the asphalt folks were keenly interested in finding a way to turn the job over to a conscientious and indefatigable electronic employee.

(If at this point it comes as a shock to you to read that Hays Corporation came up with the answer to this problem, you just haven't been absorbing our message these past several months.)

Such, however, was the case. We worked out a simple proportioning device involving two of our Veriflow meters and one Veritrol control. This new unit (see shirt-cuff sketch below) has brought automation to asphalt.



In case you aren't familiar with the operation of our Veriflow Control system, briefly this is the story. Each Veriflow meter contains a Niagara liquid displacement meter and an electric generator which produces an electric impulse, related to the flow through the meter.

A dual-wire potentiometer in the Veritrol controller measures any difference between the voltages generated by the two Veriflow meters and feeds a signal to the input circuit of the Veritrol electronic relay. This electronic relay operates a power unit controlling a butterfly valve which regulates water flow. The set-point control of the Veriflow may be adjusted to the various water-asphalt ratios required for different applications.

Our friends report that the system is working perfectly—in fact they've even added two more Veriflow meters to gauge the flow of asphalt mixed with crushed stone for road construction.

For further information on the highway program, write your congressman. For an 8-page publication on our Veriflow meter, write me for bulletin #54-766-38.

Unabashed Teaser

Would you be interested in a four-pen, circular chart electronic recorder of modular design, which can record a-c or d-c signals with the following accuracies:

Linear input: ±0.2% of scale for spans down to 10 millivolt. ±20 micro-volts for spans less than 10 mv.

Square law input: ±0.25% of scale span, or 25 micro-volts (whichever is greater) between 10% and 100% of scale span.

Sensitivity: ±0.1% of scale span, or ±10 micro-volts (whichever is greater).

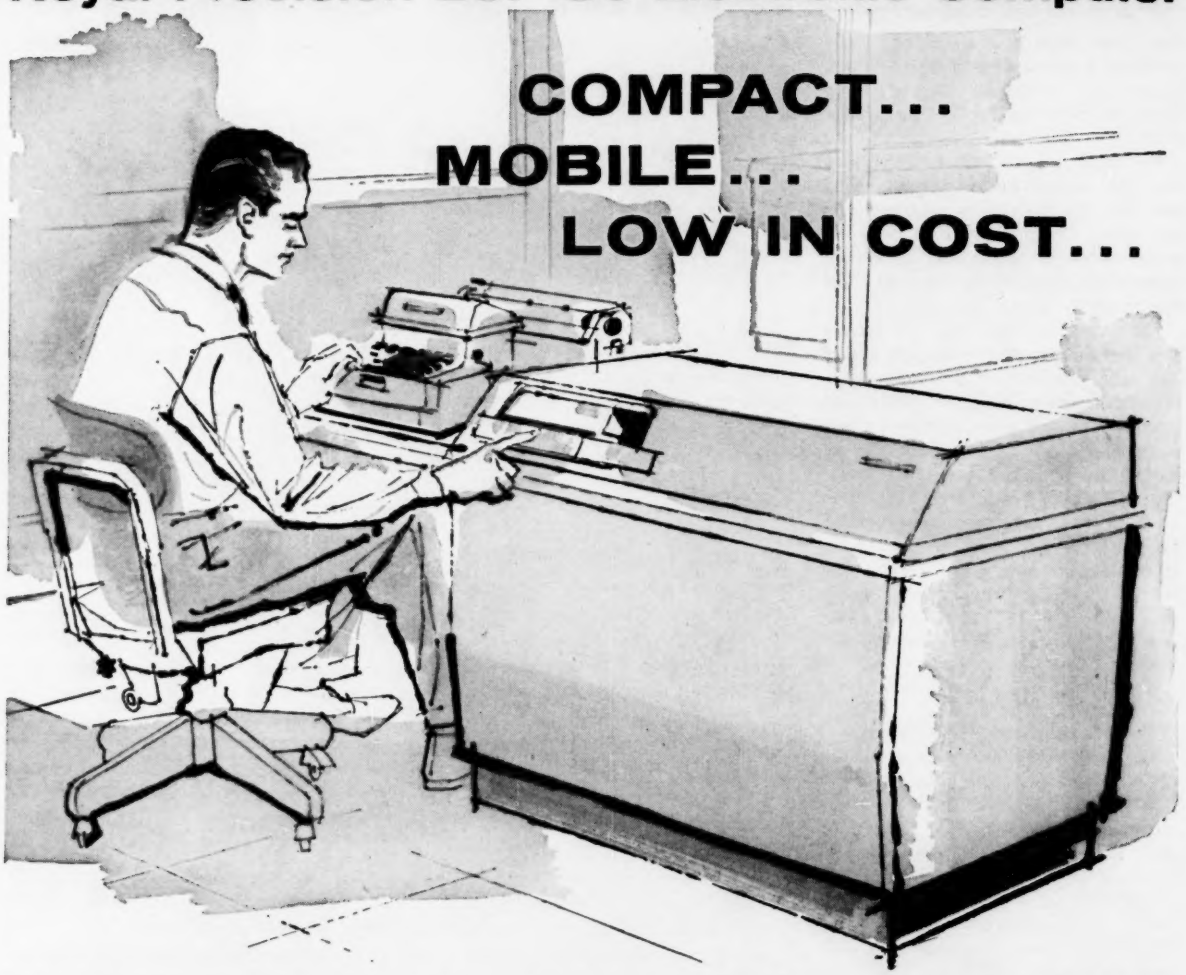
Sound interesting? Watch this space for further developments.

Phil Sprague Jr.
President

THE HAYS CORPORATION • MICHIGAN CITY, INDIANA

For more information circle 8 on inquiry card.

Royal Precision LGP-30 Electronic Computer



high-speed computation right at your desk

The result of 20 years' experience in the design of electronic computers, LGP-30 puts you in complete control of your own engineering problems. Used right at your desk, LGP-30 allows you to program your own material without planning in detail. You modify equations on the spot, follow your work to completion. Thus, you eliminate much detailed calculation . . . uncover added time for creative engineering.

Ease of operation. LGP-30's simple command structure offers the same complete internal programming found in computers many times its size and cost. Internally binary, serial, single address . . . LGP-30 enters and reports alpha-numeric information by punched paper tape or keyboard.

Greatest capacity in price range. The most powerful stored program computer of its size yet developed, LGP-30 has a magnetic drum "memory" of 4096 words. Fully automatic, it performs sub-routines . . . executes self-modifying programs.

Exceptional flexibility. LGP-30's wide range of applications includes double precision abstractions; compiling and diagnostic routines; 3-address interpretive routine with floating point abstractions; matrix operations including inverting and Eigen value problems; basic trigonometry and log functions; square root and roots of polynomials.

Nation-wide sales and service. Detailed analysis of your requirements is available through Royal McBee's nation-wide staff of trained applications engineers.

Outstanding features of LGP-30

- Operates from regular wall outlet (110 volts AC).
- No expensive installation . . . no external air conditioning.
- Unusually large "memory"— 4096 words.
- Word length: 32 bits, including sign and spacer bit.
- Average access time: 8.5 ms.
- Optimum access time: 2 ms.
- Lowest cost ever for a "complete" computer.
- Nation-wide sales and service.

For further information, write Royal McBee Corporation, Data Processing Equipment Division, Port Chester, N. Y.

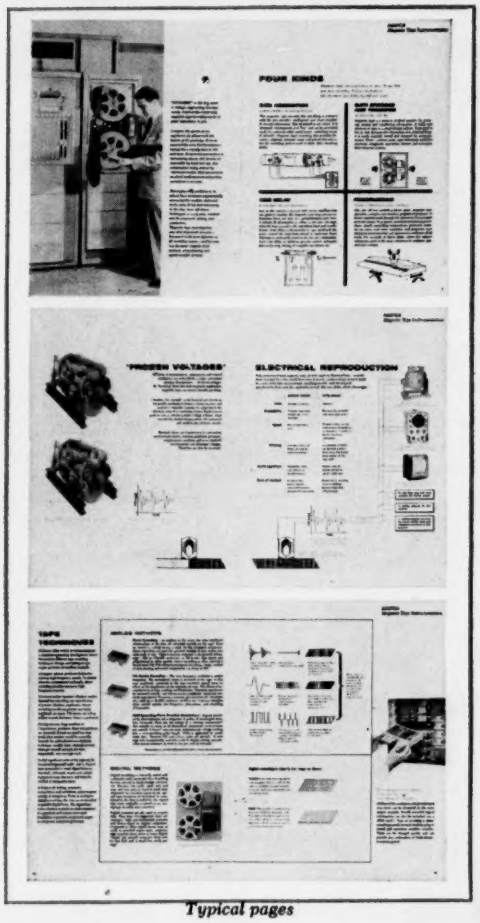
ROYAL McBEE
CORPORATION
ROYAL TYPEWRITERS • McBEE BUSINESS SYSTEMS

For more information circle 9 on inquiry card.

How to be a magnetic tape recording expert

Introducing a useful new brochure on tape in instrumentation

Tape is the stuff of which memories are made — the versatile data memories for a jet propelled age of electronic miracles. If you are one who keeps up with times and techniques, it is a field well worth knowing. This new brochure gives a wide-angle view of the whole subject.



Typical pages

What kinds of applications do you think of when magnetic tape recording is mentioned? Sound recording, of course, and telemetering, if you are in that business. But what about simulating a rough road to test truck axles, controlling a milling machine to cut an aircraft wing section out of a solid billet, monitoring for a sudden occurrence that may happen only once in a year or two, recording data that can be reduced to graphs and tabulations without ever being touched by human hands? These and many more are described.

How significant is the fact that magnetic tape recording reproduces data in the same electrical form in which it was recorded? Enormously important, when you realize all the things the reproduced data can do that couldn't be done with the original signals or with the common forms of visual recording. For example the data can be slowed down to look at fast transients. It can be speeded up for wave analysis. It can be read out in any form. A tabular comparison between original signals and taped signals gives the full story. And a step-by-step pictorial demonstration of magnetic tape recording and reproduction puts the electrical-data idea into tangible, easily visualized form.

What does the data on magnetic tape look like? You can't see it, but the brochure will give you an idea of what it would be like if you could. And incidentally this may help to clarify the differences between various magnetic-tape-recording techniques.

Do you talk in tape's language? When is a tape recorder not a recorder? What is the difference between a channel and a track? What is a servo speed control? A much needed glossary gives the consensus of our views on terms.

For whom did we write this booklet . . . the expert, or the man for whom the whole subject is new? Both. It is written and illustrated so that any engineer or technically trained person can readily grasp the concepts and gain a broad understanding of the subject. If you are one of those who has already worked extensively with tape, you will find some new twists in the way the subject is explained, and perhaps ideas on new areas you hadn't explored. And incidentally, a copy of this brochure in some handy file will give you a good start in indoctrinating that new man in the department.

For your copy, write us today on your company's letterhead. Address your request to Department BB-5

AMPEX CORPORATION

FIRST IN MAGNETIC TAPE INSTRUMENTATION

934 CHARTER STREET · REDWOOD CITY, CALIFORNIA

District offices serving all areas of the United States and Canada; Foreign Representatives in countries around the world.

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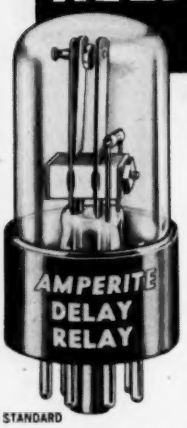
in AMPERITE *RELAYS and REGULATORS*

Simplest • Most Compact • Most Economical



STANDARD

MINIATURE

Thermostatic DELAY RELAYS

2 to 180 Seconds

- Actuated by a heater, they operate on A.C., D.C., or Pulsating Current.
- *Hermetically sealed.* Not affected by altitude, moisture, or other climate changes.
- *SPST only* — normally open or normally closed.

Amperite Thermostatic Delay Relays are compensated for ambient temperature changes from −55° to +70° C. Heaters consume approximately 2 W. and may be operated continuously. The units are *most compact, rugged, explosion-proof, long-lived,* and — *inexpensive!*

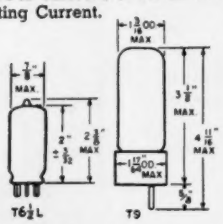
TYPES: Standard Radio Octal, and 9-Pin Miniature

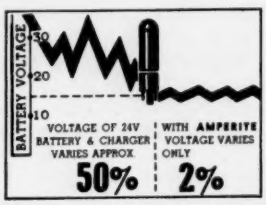
PROBLEM? Send for Bulletin No. TR-81

Also — **Amperite Differential Relays:** Used for *automatic overload, under-voltage* or *under-current protection.*

BALLAST REGULATORS

Amperite Regulators are designed to keep the current in a circuit ***automatically regulated*** at a definite value (for example, 0.5 amp.) ... For currents of 60 ma. to 5 amps. Operate on A.C., D.C., Pulsating Current.





T9 BULB

Hermetically sealed, they are not affected by changes in altitude, ambient temperature (−55° to +90° C.), or humidity ... Rugged, light, compact, most inexpensive.

Write for 4-page Technical Bulletin No. AB-51

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Individual inspection and double-checking assures top quality of **Amperite** products.

For more information circle **11** on inquiry card.

Inquiries

These inquiries, representing problems facing readers of **Instruments & Automation**, are published as a free service to our readers.

Magnetic Amplifiers

Electrical-engineering student would like to obtain literature on magnetic amplifiers. A-244

Dynamometer

Director of medical equipment company seeks device which connected in series with motor would indicate whether motor is under load or idling. A-245

Motor Control Circuits—Infrared Bibliography

Reader seeks information on light-duty motor control circuits; also book listings on infrared techniques. A-246

Rotary Solenoid Valve

Canadian research institute seeks four-way, two-position, reversing rotary solenoid valve to handle air flows of 40 cu in/sec with a minimum of pressure drop. Burst pressure: 10 psi. A-247

Push-Pull Servo Amplifier

Reader in Great Britain wishes to build 115-v, 400-cps push-pull servo amplifier for use with servomotor, size 18, BuOrd Mk. 8, Mod. O; control transmitter, size 11, BuOrd No. 11CX4A, Mk.41,Mod. I; and control transmitter BuOrd No. 11CT4A,Mk.24, Mod.I. Amplifier is to give 9-w output to control phase of servomotor. Information on circuit and output transformer are requested. A-248

Aircraft Instrument Servicing

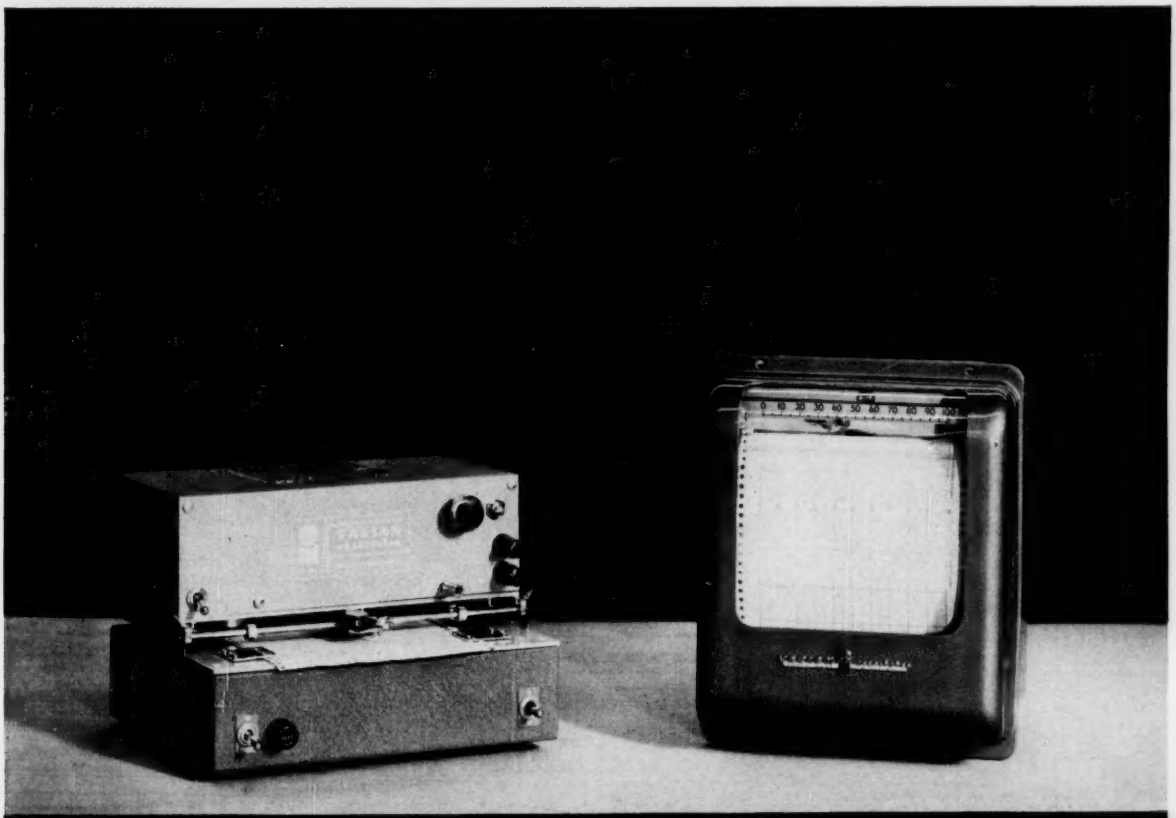
Reader setting standards and developing methods for large overhaul depot is interested in obtaining literature on aircraft instrument servicing. A-249

Small Gas Flow Element

Research engineer in atomic energy lab seeks gas flow element for viscous flow with linear (not square root) differential-pressure relationship. A-250

Varian Strip Chart Recorders

POTENTIOMETER PERFORMANCE* AT MODERATE COST



Varian G-10 Varian G-11

* The servo-balance potentiometer method has long been used in expensive recorders to achieve superior stability, sensitivity, ruggedness and high input impedance. Use of servo balancing systems assures full realization of these inherent advantages by providing ample power independent of the source being measured. Now Varian offers you recorders of moderate cost using this time-proven principle.

VARIAN SPECIFICATIONS:

- Spans as low as 10 mv
- Limit of error 1%
- Maximum source resistance 50K ohms or higher
- Balancing times: 1 second or 2.5 seconds on G-10; 1 second on G-11

WRITE TODAY FOR COMPLETE SPECIFICATIONS

Varian recorders are sold and serviced throughout the free world by representatives in principal cities.

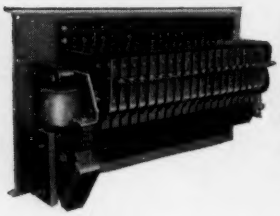
VARIAN associates
INSTRUMENT DIVISION
PALO ALTO 27, CALIFORNIA

Varian Associates manufactures Klystrons, Traveling Wave Tubes, Backward Wave Oscillators, Linear Accelerators, Microwave System Components, R. F. Spectrometers, Magnets, Magnetometers, Stalos, Power Amplifiers and Graphic Recorders and offers research and development services.

For more information circle **12** on inquiry card.

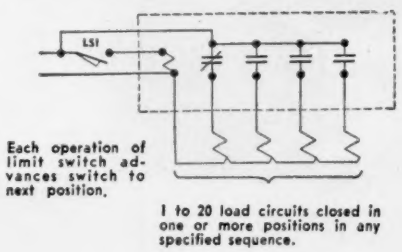
NEW EAGLE STEP SWITCH SIMPLIFIES CIRCUIT SEQUENCING

. . . for machine tools, presses, conveyors, processes

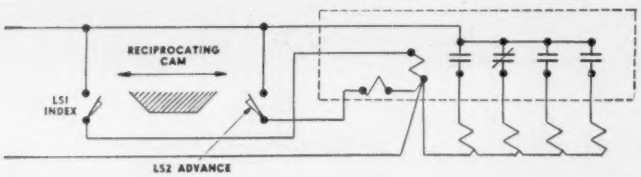


These 3 basic ideas are yours for simplified interlocking or sequencing of multiple load circuits. Any and all three will eliminate many other electrical components, and cut your initial cost.

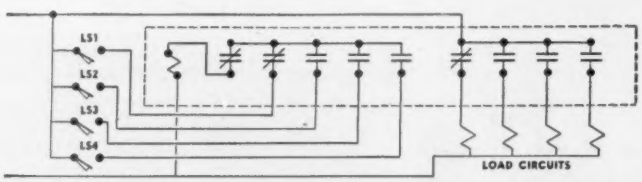
Operating load circuits in sequence: A limit switch on a machine or indexing device closes and opens upon each operation to advance the Eagle step switch. Or a timer may be used to operate each load circuit for a predetermined time.


LS1
Each operation of limit switch advances switch to next position.
1 to 20 load circuits closed in one or more positions in any specified sequence.

Interlock sequence: *Two limit switches* are operated alternately. This provides a safety feature. It insures that the movement of the machine has been completed before the Eagle step switch advances.



Interlock sequence with several limit switches: Each limit switch advances the Eagle step switch one position. Switches must operate in sequence or the step switch won't advance.



Send for new Eagle Bulletin 850. Simply write to Eagle Signal Corporation, Industrial Timers Division, Moline, Illinois, Dept. IA-757.

For more information circle **13** on inquiry card.

INQUIRIES—CONTINUED

Spray-on Photoelectric Material

Research associate at university seeks spray-on material to convert three-dimensional wooden models into photoelectric cells, taking current off through attached lead wires. Alternately, foil layers would be acceptable. A-251

High-Powered Telescope

Reader wishes to mount high-powered telescope on trailer to assist church program. Seeks sources of supply. A-252

Market Place

Precision Step Motor

Single-phase step a-c motor featuring infinitely variable speed in either direction, with dynamic braking, high torque, precision positioning to any desired accuracy (using digital techniques), and capable of maintaining absolute relative synchronism between similar motors, has been developed, tested and patent protected. Patent holders seek interest or manufacturing assistance from interested equipment manufacturers, groups, or venture capital. Write Market Place, c/o Instruments Publishing Co., 845 Ridge Ave., Pittsburgh 12, Pa.

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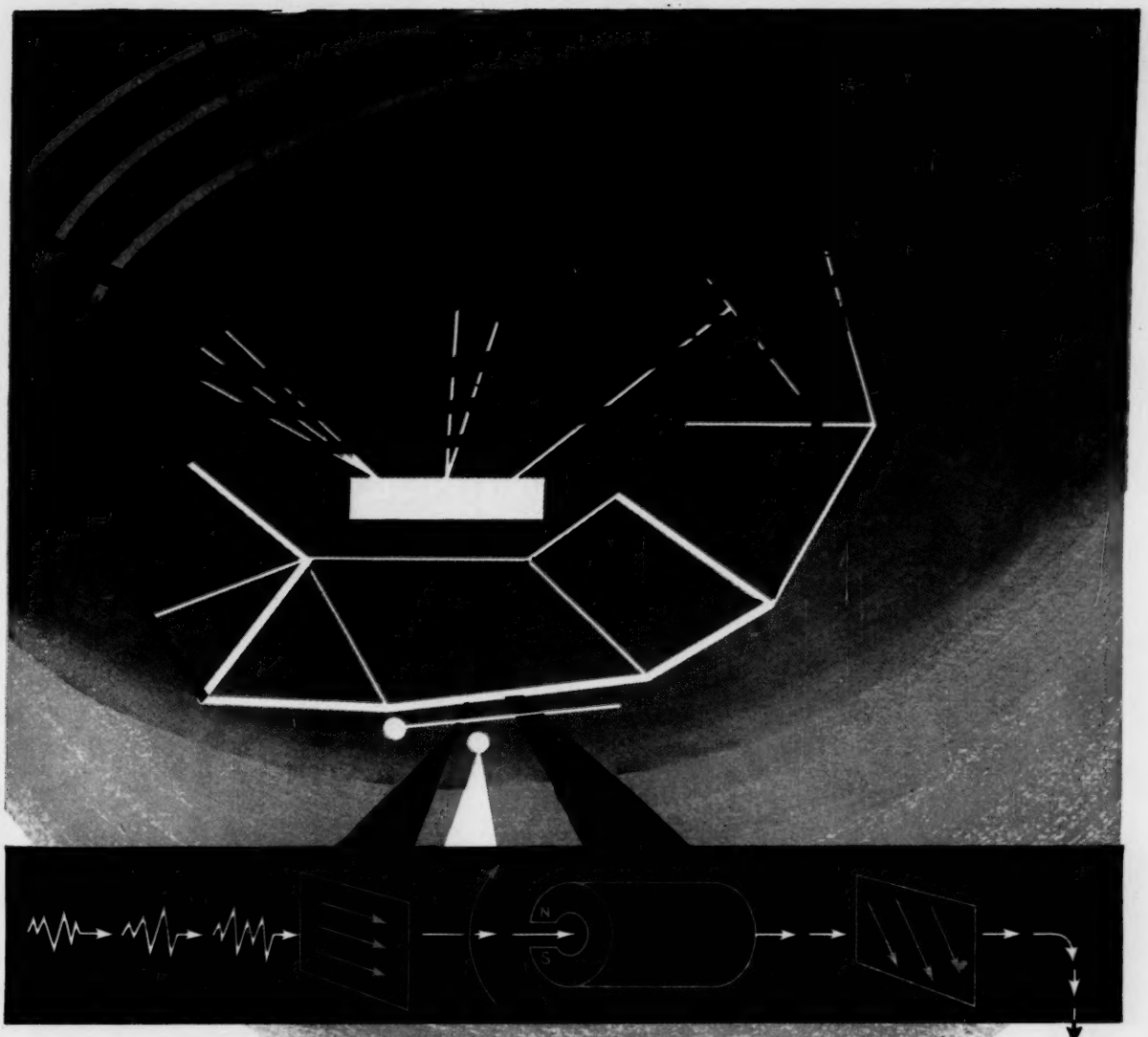

in radar load isolators, too

CRUCIBLE PERMANENT MAGNETS

give maximum energy. . . minimum size

Special applications, such as radar load isolators, demand compact but powerful magnet assemblies. And this is but one of the many places where the *consistently* higher energy product provided in Crucible Alnico magnets pays off.

These Crucible Alnico permanent magnets can be sand cast, shell molded, or investment cast to exact size, shape or tolerance requirements . . . and in any size from a mere fraction of an ounce to hundreds of pounds.

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For more information circle **14** on inquiry card.

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601
602

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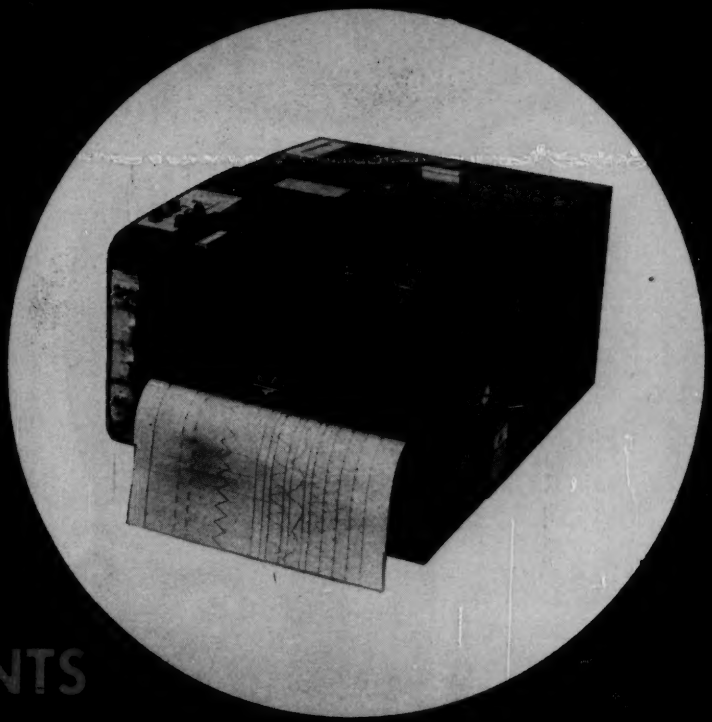
SPECIFICATIONS

MAXIMUM NUMBER OF CHANNELS	Model 601—36 Channels Model 602—50 Channels
RECORD WIDTH	Model 601— 7 inches Model 602—12 inches
MAGAZINE CAPACITY	Model 601—150 feet Model 602—200 feet
RECORD SPEED RANGE	0.0812 to 129.9 inches per second
FREQUENCY	dc to above 3,000 cps
WRITING SPEED	Above 30,000 inches per second
OPTICAL ARM	11 inches
POWER REQUIREMENTS	110 volts—60 cps
TIMING LINES	0.01 and/or 0.10 second intervals
SIZE	Model 601—11 1/16 x 11 9/16 x 23" Model 602-11 1/16 x 16 13/16 x 24 1/2"
WEIGHT	Model 601— 90 pounds Model 602—130 pounds

For more information circle **15** on inquiry card.



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Seven inch or twelve inch records

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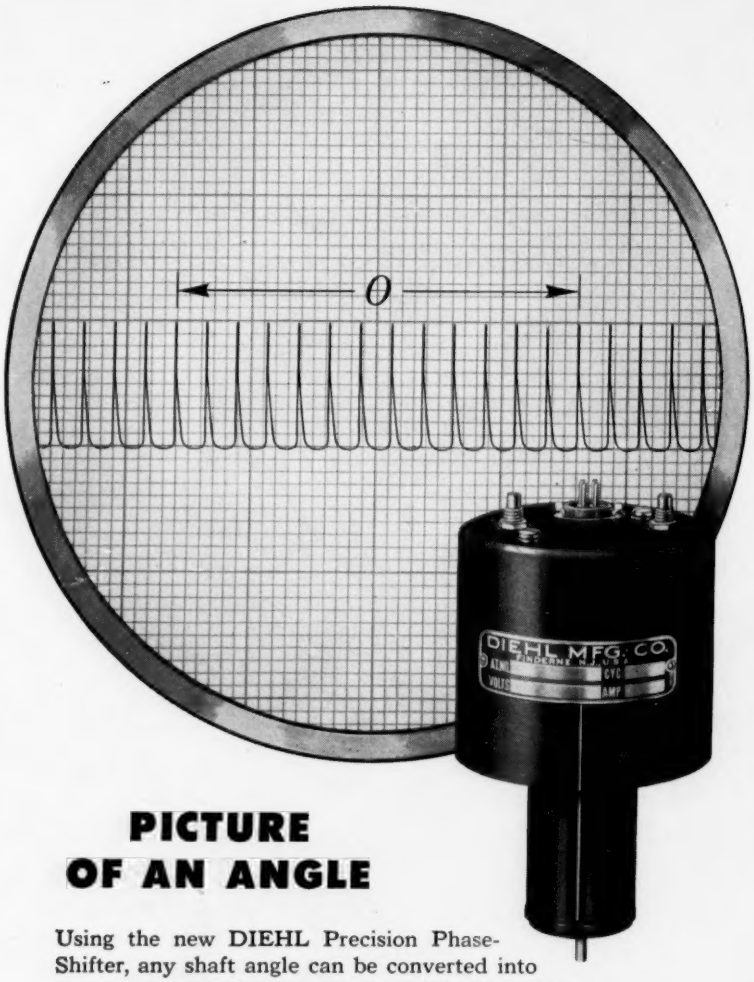

PICTURE OF AN ANGLE

Using the new DIEHL Precision Phase-Shifter, any shaft angle can be converted into an accurate *digital* presentation like the pulse train shown above. In such use, a separate high frequency counting signal is triggered by the reference wave and shut off by the phase-shifted wave, thus identifying a shaft angle with a finite number of pulses. Small size and simplicity make this Phase-Shifter ideal for use as an Analog-to-Digital Converter component.

This is only one of many applications for the DIEHL Precision Phase-Shifter which can now be provided for any fixed frequency between 60 cps and 4 megacycles.

By combining the very accurate DIEHL Size 11 Resolver with the appropriate circuitry, accuracies of better than ¼ of a degree have been attained at frequencies up to 100 Kc. Phase shift is continuous through 360° and variation of output amplitude is held to a minimum.

To insure that the accuracy of the Phase-Shifter is not influenced by external loading, a cathode follower circuit is incorporated in the network to isolate the unit.

Send for additional engineering data.

Diehl

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other available components

• AC SERVOMOTORS • AC SERVOMOTORS WITH AC TACHOMETERS • DC SERVO SETS
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BOOTH 1303—1957 WESCON, SAN FRANCISCO, AUGUST 20-23

For more information circle **16** on inquiry card.

Events

August 20-23

Western Electronic Show and Convention, Cow Palace, San Francisco, Calif. For information write Western Electronic Show and Convention, 342 N. La Brea Ave., Los Angeles 36, Calif.

August 26-30

Eighth Annual Infrared Spectroscopy Institute, Fisk University, Nashville 8, Tenn. For information write Nelson Fuson, Infrared Spectroscopy Institute, Fisk Univ., Nashville, Tenn.

August 28-30

National Gas Chromatography Conference, Michigan State University, Kellogg Center, E. Lansing, Mich. For information write I.S.A., 313 6th Ave., Pittsburgh, Pa.

September 4-6

Magnetic Amplifiers Conference of the Institute of Radio Engineers-American and the Institute of Electrical Engineers, Penn Sheraton Hotel, Pittsburgh, Pa. For information write AIEE, 33 W. 39th St., N. Y. 18, N. Y.

September 9-13

12th Annual ISA Conference & Exhibit, Auditorium, Cleveland, Ohio. For information write William Kushnick, 313 Sixth Ave., Pittsburgh 22, Pa.

September 23-25

6th Annual Meeting of the Standards Engineers Society, Hotel Commodore, New York, N. Y. For information write Standards Engineers Society, Box 281, Camden 1, N. J.

September 24-25

Industrial Electronics Conference, sponsored by the Institute of Radio Engineers and American Institute of Electrical Engineers, Morrison Hotel, Chicago, Ill. For information write A.I.E.E., 33 W. 39th St., New York 18, N. Y.

October 7-9

National Electronics Conference, Hotel Sherman, Chicago. For information write National Electronics Conference, 84 E. Randolph St., Chicago 1, Ill.

October 10

Reliability and Quality Control in Electronics conference of the A.I.E.E., Silver Springs, Md. For information write A.I.E.E., 33 W. 39th St., New York 18, N. Y.

October 17-18

National Conference on Industrial Hydraulics, Sherman Hotel, Chicago, Ill. For information write Armour Research Foundation, Illinois Institute of Technology, 10 W. 35th St., Chicago 16, Ill.

October 24-25

Computer Applications Symposium, Sherman Hotel, Chicago, Ill. For information write Armour Research Foundation, Illinois Institute of Technology, 10 W. 35th St., Chicago 16, Ill.

November 2-10

INTERKAMA (International Congress and Exhibition of Measuring Instrumentation and Automation), Dusseldorf, Germany. For information write Nordwestdeutsche Ausstellungs-Gesellschaft m. b. H., Ehrenhof 4, Dusseldorf, West Germany.

November 6-8

I.R.E. 1957 Aero-Com Symposium, Hotel Utica, Utica, N. Y. For information write R.A. Zachary, Vice Chairman for Technical Program, 11 Arbor Drive, New Hartford, N. Y.

November 7-8

Louisiana Polytechnic Institute 6th Annual Instrumentation Conference, Louisiana Polytechnic Institute, Ruston, La.

November 11-13

Instrumentation Conference and Exhibit, Institute of Radio Engineers, Biltmore Hotel, Atlanta, Ga. For information write B. J. Dacher, School of Electrical Engineering, Georgia Institute of Technology, Atlanta, Ga.

December 8-11

Eastern Joint Computer Conference, sponsored by IRE, AIEE and Assn. for Computing Machinery, Shoreham Hotel, Washington, D. C. For information write Morton M. Astrahan, IBM Corp., San Jose, Calif.

May 31-June 8, 1958

European Congress of Chemical Engineering and ACHEMA Congress, Frankfurt a.M., Germany. For information write DECHEMA, Dechema-Haus, Rheingau-Allee 25, Frankfurt a.m., West Germany.

June 9-13, 1958

Fourth International Automation Exposition, Congress, Conferences, and Clinics, New York Coliseum. For information write Richard Rimbach Associates, 845 Ridge Ave., Pittsburgh 12, Pa.

Blue Ribbon Precision

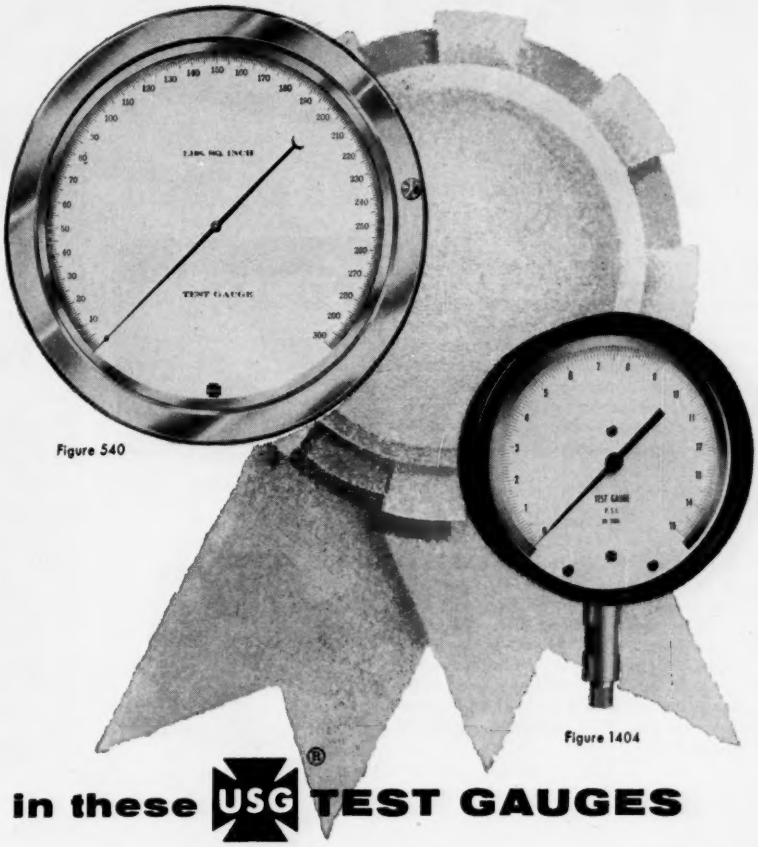

Figure 540

Figure 1404

in these USG® TEST GAUGES

The new 1400 Series gauges have a wide range of applications . . . for test cells and panels . . . for portable testers . . . for checking and calibrating gauges in service . . . for laboratory work not requiring readability of 12″ or 16″ gauges.

Available in 4½″, 6″ and 8½″ dial sizes with ranges from 30″ Hg. Vacuum to 5000 psi, for stem (Fig. 1404), wall (Fig. 1400T), or panel (Fig. 1402) mounting.

Accuracy—¼ of 1% of scale guaranteed.

Laboratory Test Gauges Fig. 540—12″ and 16″—have long been recognized as the master calibration standard. Because of their precision, they are frequently used to replace or augment dead weight testers or manometers.

For details on USG's complete line of Test Gauges, write for Catalog 400, or call the USG sales office or distributor in your area. See the "Yellow Pages" of your telephone directory.

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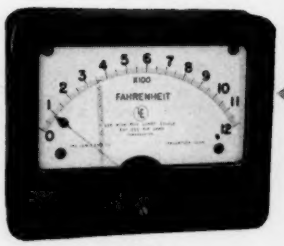
For more information circle **17** on inquiry card.

LEWIS

AUTOMOTIVE AND INDUSTRIAL TEMPERATURE MEASURING EQUIPMENT

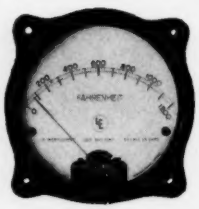
Sturdy Dependable Indicators —Suitable For Use In Moving Vehicles or For Permanent Installation

This instrument has been used extensively by the leading motor-car manufacturers for road testing on the "Proving Grounds" — where performance counts. Housed in a rectangular bakelite case, this reliable, fully compensated pyrometer is furnished with 6 in. hand drawn scales for greater accuracy. The Model 58PY is available for use with all standard thermocouple materials, in many ranges to suit the most exacting application.



MODEL 58PY

Manufactured with the same type of movement as our aircraft pyrometers, the Model 23B pyrometer is well suited for use in moving vehicles and has been successfully used in many marine diesel installations for measuring exhaust temperatures. It is housed in a 4 in. round bakelite case that is flanged for panel mounting, and is available in several ranges for use with various thermocouple matericls.

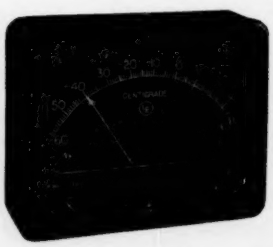


MODEL 23B

The Model 20B series of indicators are patterned after our standard aircraft instruments and are supplied with 3" round steel cases suitable for panel installation. These compact, sturdy indicators have 2⅛ in. scales, are fully cold-end compensated and are available in many ranges for use with various thermocouple materials.

MODEL 20B

The Model 62RT4F resistance thermometer is a sturdy easy-to-read instrument with a 6 in. hand drawn scale. It is suitable for use in moving vehicles and is excellent for flight-test work. It is operated by an ordinary dry cell and is calibrated to standard "AN" bulb curves for various ranges in fahrenheit or centigrade.



MODEL 62RT4

THERMOCOUPLES for use with the above indicators are available in many styles for special applications. We have developed a complete line of aircraft, industrial and automotive thermocouples and would be pleased to offer our recommendation for your application.

THERMOCOUPLE LEAD WIRE for connecting thermocouples to the indicators is manufactured in iron-constantan, copper-constantan or chromel-alumel material with standard and special insulation. Use Lewis lead-wire with Lewis instruments and thermocouples for best results.

RESISTANCE BULBS for use as sensing elements for the 62RT4 thermometers are available in several types for various applications, for measuring free air or liquid temperatures. We invite inquiries on your application.

THE LEWIS ENGINEERING CO.

Specialists in Electrical Temperature Measurements

NAUGATUCK, CONNECTICUT

For more information circle **18** on inquiry card.

INSTRUMENTS and AUTOMATION Trends

Analog computer market is now $32-$35 million annually, according to I&A survey. There is now about $80 million worth of general-purpose analog-computer installations in operation in the U.S.A. Although aircraft industry has been largest user to date, industrial market may explode by 1960. Total annual volume by 1960 should be near $100 million; $200 million by 1965. The market has doubled each year and is expected to continue to do so for some time.

Digital computer market is $350 million in 1957, says Fortune survey; may hit $1 billion by 1960; $2 billion by 1965. Business applications predominate—and are expected to remain largest market. Eighteen companies produce the computers; ten of which are "large." Leading companies are (1) IBM, (2) Rem-Rand, (3) Burroughs-Electrodata, (4) National Cash Register, (5) Philco, (6) Datamatic, (7) RCA.

More than 3000 punch-card calculators, 400 medium-speed general-purpose digital computers, and 130 high-speed general-purpose digital computers were in operation in U. S. by end of 1956, says American Peoples Encyclopedia Yearbook. Unfilled orders for data-processing machines for business (not engineering) totaled $250 million (Editor's note: figure of 400 medium computers seems low. For example, 700 IBM 650's are already said to be installed).

Electronics industry does $11.5 billion annually, says Fortune, with 1.5 million employees (570,000 in manufacturing), compared with $1 billion and 150,000 employees in 1939. Industry is now 5th largest, behind only automotive, steel, aircraft, and chemicals; is ahead of the electrical industry. Industry may reach $16-22 billion by 1965.

Machine-tool shipments in 1956 approached $900 million; are expected to exceed $1 billion in 1957. Metal-working industries produced goods worth $120 billion in 1956.

Digital techniques are growing rapidly in importance—multiplexing, counting, computing, gating, logic circuitry, etc., and causing growing interest in switching devices, the heart of all digital techniques. The vacuum tube (flip-flop) is giving way to transistors and cores. These may give way in future to new chemical and photographic switch techniques, analogous to biological components such as neurons and brain tissue. One chemical switching device comprises microscopic capsule with only light energy needed to activate the compound.

GEOPHYSICAL exploration is about $400 million annual market, reports society of Exploration Geophysicists, of which $15 million is for instrumentation. About $250 million of the $400 million is spent in U.S., rest abroad. Seismograph equipment costs about $50,000 per crew. Seismography market in 1956: $2.4 million; airborne magnetic survey: $2.2 million; electro-magnetic survey: $1.6 million; radioactivity surveys: $0.9 million.

Eardrums can sometimes double as pressure gages . . . BUT

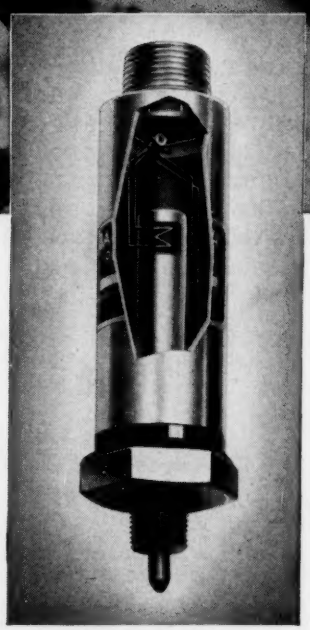
Use SR-4® Fluid Pressure Cells to measure and control all industrial pressures . . . safe, rugged, accurate to ± ¼%

The skin diver's eardrums are a kind of "go no-go" gage that tells him when he's down as far as he can go. But popping eardrums aren't recommended for performing accurate industrial pressure measurements!

SR-4 Fluid Pressure Cells will measure absolute or differential pressures consistently to less than ± ¼% accuracy! Using well-known SR-4 Bonded Wire Strain Gages, these transducers convert pressure changes directly into a varying electrical signal. This signal can be fed to Baldwin indicators, recorders, controllers or other instruments in a system. There are no moving parts to wear out, no long pressure lines with possible leakage and fire hazards. Remember, a system is only as accurate as its transducer.

If you have pressure measurement problems, a B-L-H representative will be happy to help you—in selecting the proper transducer or in engineering a complete pressure measuring system.

Write today to Dept. A for your free copy of Bulletin 4306, showing the wide range of SR-4 Fluid Pressure Cells.



SR-4 Fluid Pressure Cells are made in standard units with capacities as low as 15 psi and as high as 50,000. With pressure converted to proportional electrical voltage, the instruments for reading changes may be located at any remote point.

BALDWIN · LIMA · HAMILTON

Electronics & Instrumentation Division

Waltham, Mass.

SR-4® strain gages • Transducers • Testing machines

For more information circle **19** on inquiry card.

THE INSTRUMENT SALESMAN PREPARES FOR THE FUTURE

Panhandle Pete

T.G.I.F. May 24. Sitting around the office, picking my teeth, waiting for the Boss to go home so I can too. Big week-end lined up: going to move into new house Saturday; playing golf Sunday morning with "Horse" McNulty—he needs another encoder and I can sell him one on the golf course; going fishing Sunday afternoon with old Frat brother—mustn't forget to put some of my good West Virginia whiskey on ice to-day; playing bingo Sunday night for some patriotic and charitable organization —funny thing, we are playing at a deserted schoolhouse out in the strip mines back of McKeesport and have to give a secret password to get in. Don't know why.

Wait 'til the old lady sees the automatic built-in oven, surface units and dish washer I ordered for the new house. All automatic, as befits the best instrument salesman in the industry. Yes sir, she'll stop her griping about my ordering new automatic equipment when she sees these units. I can't wait to slip the units into the holes I dug out of the kitchen walls for them. The salesmen promised me faithfully the units would be there when we move in tomorrow; he wouldn't let me down.

"Hey, you there, wake up!" shrieked a voice in my ear, interrupting my beautiful thoughts, "Come in here!"

"Oh it is you Boss? Sure what's up? Somebody want to buy something?"

"Of course not, you idiot, I handle those kinds of sales," snapped the Boss. "Here's a request in the mail for a commencement speaker down in Charleroi, my old home town, for to-morrow at noon. . ." "But Boss," "Shut up! They want a talk on the word *Automation* and you are the expert. . ." "sure Boss, but," "I've selected a theme for you—"Prepare for the Future Because Times are Changing Rapidly." You go home now and prepare the speech! Remember, Prepare for the Future!"

"Yes, but Boss, I'm moving tomorrow and I don't have time to, that is, I'll be awful busy and my wife, Oh Hells bells, do I hafta go?"

Up bright and early Saturday in time to personally unhook the stove and throw it over the hill. Told wife not to worry about it—new built-in units will be in the new house in a few hours. Sure glad to get rid of that old wreck. Left just ahead of the movers, two hours ahead of time so I would be prepared for the future. I practice what I preach!

Just got a good start down the hill on route 51 past the distillery where the railroad crosses the highway. Noticed the crossing lights flashing . . . must be out of order; hasn't been a train on this crossing in years, no use stopping, mustn't be late . . . Eeeyow! Where did that train come from? Whew, just made it across.

Got stopped in line of traffic on hill on other side of Elizabeth; State Police checking driver's licences and owner's cards. Reached in pocket for mine and . . . Oh oh, no wallet. Remembered leaving it in the drawer in the stove and . . . Stove? My gosh! I threw it over the hill. Police fairly reasonable: left my lodge pin, pivot tooth, spare glasses and spare tire for security against my return "Tomorrow with papers." Lost an hour of time already; have to hurry. Turned off route 51 onto route 71 and whizzed over to Monongahela in fine time except that I got tied up in a traffic jam on the bridge for another hour; why can't all these farmers stay home on Saturday morning?

Started up hill on route 88 out of town, noticed strange odor—must be something burning, gob pile maybe? —when a car passed me with much hornblowing and waving of arms. Hmmmm. Some Saturday drunk? Holy smokes! My car's on fire! Jumped out of car, pulled wires off, threw dirt on motor, beat fire with hat and coat and finally got it out. What a mess, no hat, no coat, no car, almost noon. . . Walked to farmhouse and persuaded farmer to drive me into Charleroi; got there at 12:30 and jokingly told the few graduates who were still waiting in the auditorium the cause of my delay before beginning the speech on "Prepare for the Future!" At that point someone started to boo and hiss and somebody else threw a tomato. Principal of school finally got order restored upon threat of withholding diplomas and I gave speech. Nobody said anything, laughed at my jokes, or even listened . . . complete flop. "Prepare for the Future!" Bah.

Sent tow-car after my auto; no mechanics Saturday afternoon. Left car at garage and went home on bus. Wife met me at door. "Where is the new kitchen unit?" Where is the icebox and stove? Where have you been?" My gosh, why are wives so curious? Went to kitchen; nothing visible but holes and pipes. Called the salesman; out playing golf. Called the factory; my kitchen unit isn't even on the production line yet. Oh my gosh. Automation! Who invented it?

Panhandle Pete

A technician from our Instrument Division calibrates an M-S-A infrared process stream recorder against our master calibration panel.

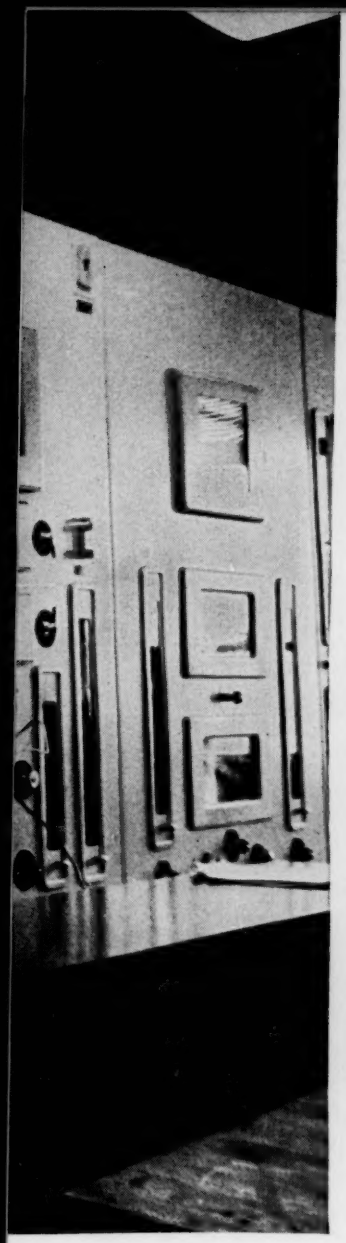
These special gas and vapor mixing concentrations for accurate calibration

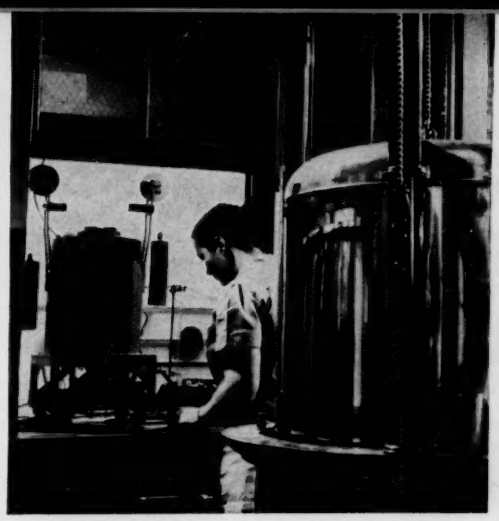
We figure that accurate calibration of M-S-A instruments to customer sample specifications is a very necessary part of doing a good job in the process stream analyzer business. It's a company policy that started back about 30 years ago when we first got into gas analysis instrumentation.

From this long-time experience, we have developed a number of skills and a variety of unique methods for making known mixtures of gases and vapors. Some of our mixing techniques are pictured and described above. The products of these mixers are delivered to newly manufactured instruments. Calibration controls are then adjusted so that the recorder or indicator accurately reports the concentration. Normally, several mixtures are made for each instrument to check its performance throughout the scale range—both for accurately reporting the gas or vapor of interest—and to determine cross sensitivities to other components of the mixture. It all makes for a high degree of unerring dependability when an M-S-A analyzer is on stream.

We apply factory calibration to all of our instruments. Our basic units are shown at the right. These analyzers are ticking away throughout industry—improving product quality, lowering processing costs, and increasing safety. MSA is a good source to begin with if you have a process stream problem. Get in touch with us soon. Write to us for helpful literature or call in one of our Instrument Specialists for more information.

For more information circle **20** on inquiry card.



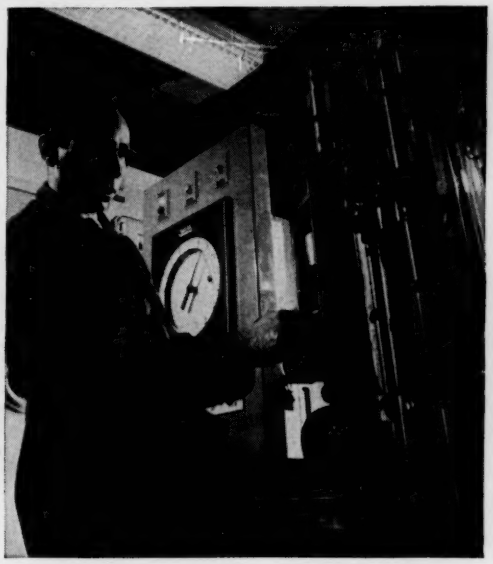


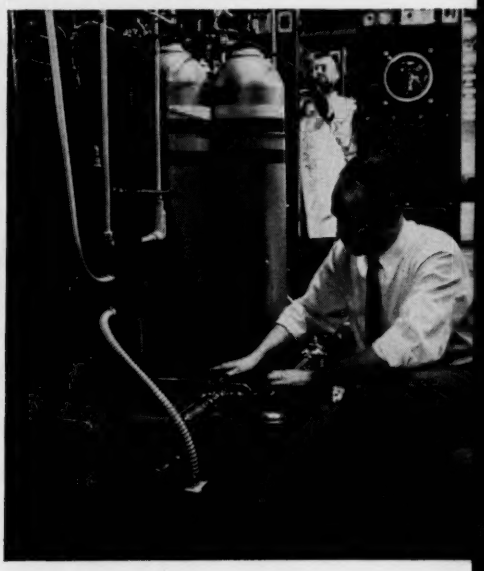
These gas holders contain synthesized mixtures which may be stored for delivery to instruments. The one at left is mercury sealed, the one at right is water sealed.

Here's still another calibrator in our stable of special mixing devices. This one is used for vaporizing liquid constituents in a gas stream.

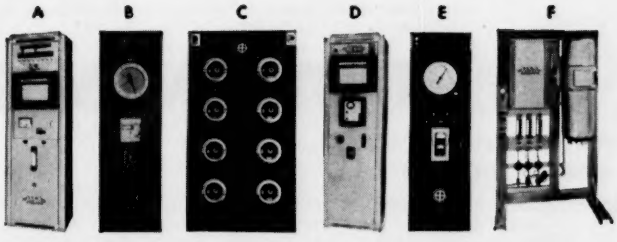
Technician above, is making a gas mixture from master panel flow meters, through which gas from several cylinders may be delivered simultaneously for calibration.

Out on the assembly floor, an MSA engineer checks a process stream analyzer against customer sample that has been synthesized in a high pressure cylinder.





facilities produce known of M-S-A® instruments



A. M-S-A (LIRA) Infrared Analyzer
B. M-S-A Hydrogen Sulphide Recorder
C. M-S-A Combustible Gas Analyzer
D. M-S-A Gas Thermatron
E. M-S-A Oxygen Indicator
F. M-S-A Water Vapor Recorder

INSTRUMENT DIVISION

MSA

MINE SAFETY APPLIANCES COMPANY

Pittsburgh 8, Pennsylvania

For more information circle **20** on inquiry card.

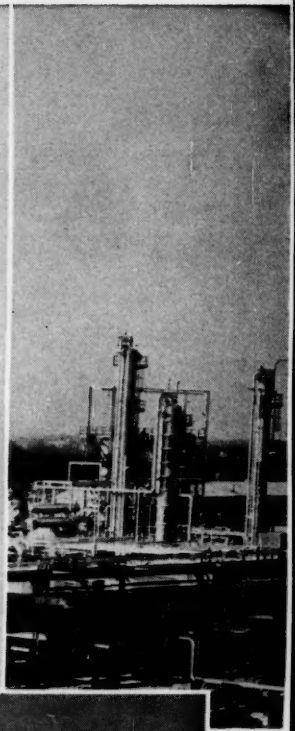
GIANT TIDEWATER REFINERY HAS ALL THREE

PROTECTION

CONTROL

MEASUREMENT

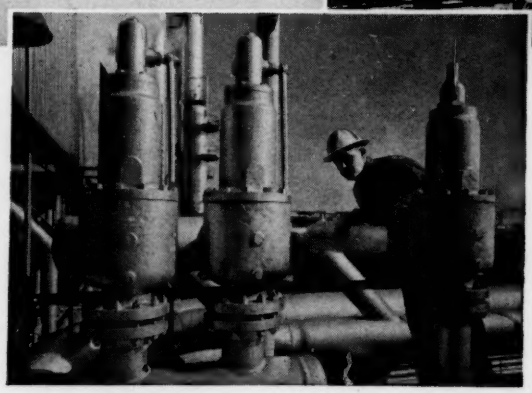
with reliable products of Manning, Maxwell & Moore



The Tidewater Oil Company's mammoth new Delaware Refinery is rightly referred to as the "refinery of the future." C. F. Braun & Co., engineering contractors, built the plant on the 5,000 acre site. Most of the processing units are unequalled anywhere for size and capacity. Tidewater incorporated the most advanced design and equipment to assure the greatest flexibility, economy and safety.

To provide around-the-clock protection, control and measurement, this ultra-modern refinery makes full use of dependable Consolidated Safety Relief Valves, Hancock Valves and Ashcroft Pressure Gauges. These products of Manning, Maxwell & Moore are precision engineered and built to insure the perfect performance, freedom from costly maintenance and long-life service so vital to economical refinery operations.

Whether you are modernizing or enlarging your plant for increased capacity . . . whether you are scheduling a "turn-around," planning a new processing unit or adding storage facilities – call on Manning, Maxwell & Moore regarding problems in protection, control and measurement. District offices and industrial distributors in the United States and Canada as well as agents and manufacturing licensees throughout the world are ready to serve you.



PROTECTION

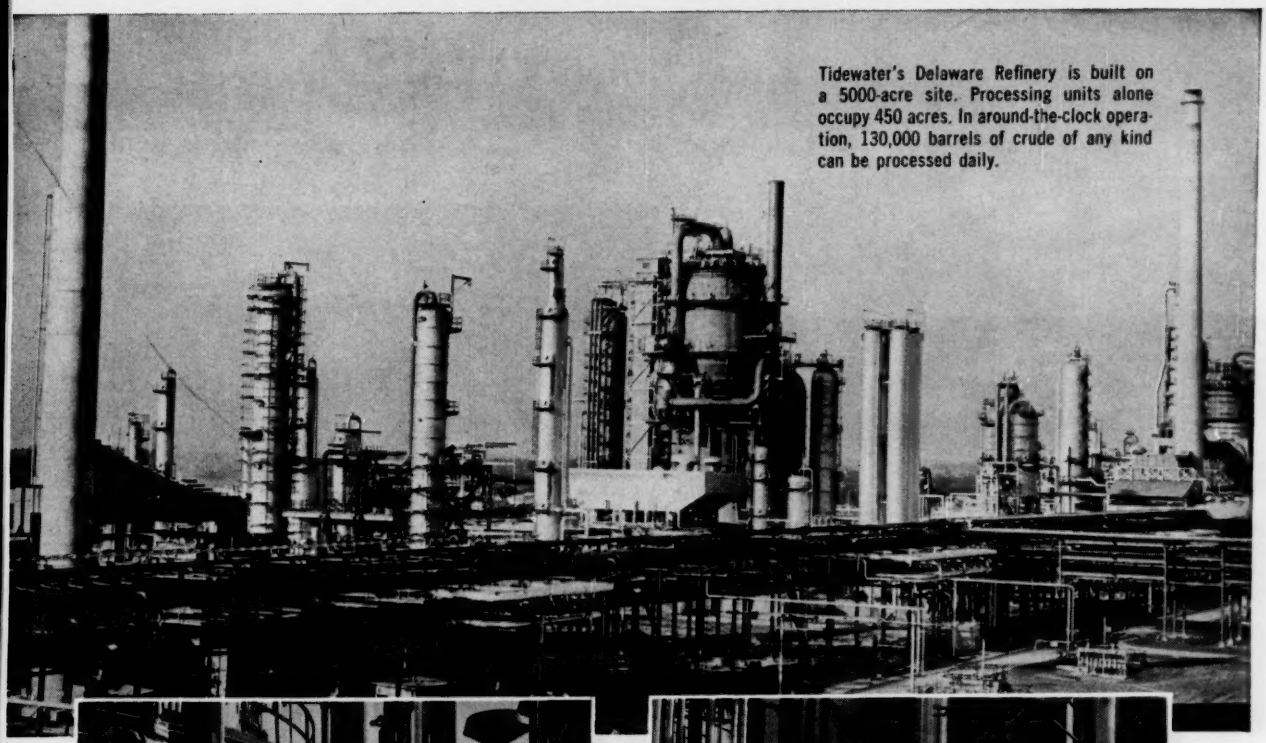
. . . by CONSOLIDATED SAFETY RELIEF VALVES. The Orthoflow fluid catalytic cracker at Tidewater's Delaware Refinery is the world's largest. It is equipped with Consolidated Safety Relief Valves as are the propane storage bullets. These valves assure absolute protection through peak performance and consistently positive action, even where "superimposed" back pressure is in the relieving system.

Consolidated Safety Relief Valves are "2 in 1" valves with interchangeability so highly perfected that the Standard valve can be converted to the Balanced Bellows Seal type *in the field.* Standardized inlet and outlet face-to-face dimensions permit these valves to be interchanged with those of some other manufacturers.

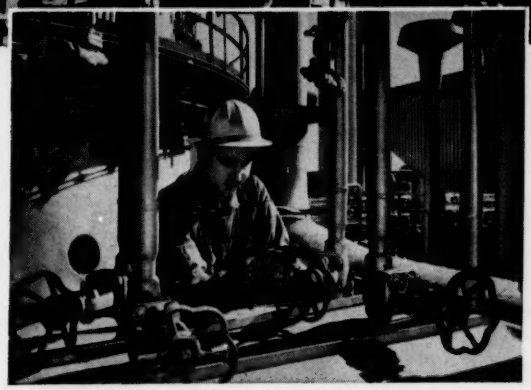
Fewer functional parts and precision machining and alignment of parts assure long valve life and less maintenance.

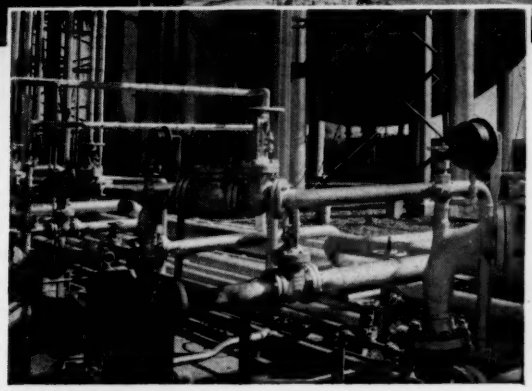
MANNING,

For more information circle **21** on inquiry card.



Tidewater's Delaware Refinery is built on a 5000-acre site. Processing units alone occupy 450 acres. In around-the-clock operation, 130,000 barrels of crude of any kind can be processed daily.





CONTROL

. . . by HANCOCK VALVES. The fluid-handling systems in Tidewater's Delaware Refinery must be kept at highest operating efficiency. To help control flow in the vast network of "fluid highways," hundreds of Hancock Valves are installed.

These manually-controlled valves are designed and built to give reliable performance under the pressures, temperatures and piping strains common to the most modern processing plant. All materials used in their construction are carefully selected — rugged strength and durability are engineered into every component. The super-hard seating surfaces are highly resistant to galling, steam cutting, wire drawing, erosion and corrosion. Positive tightness — leak-proof tightness — is assured month after month. Maintenance requirements are reduced to a minimum. Long-life service proves that there is no substitute for the economy of quality found in all Hancock Valves.

MEASUREMENT

. . . by ASHCROFT PRESSURE GAUGES. Accurate pressure measurement is essential to maintain product quality . . . to assure capacity performance of equipment and economical production in Tidewater's Delaware Refinery. Ashcroft Duragauges are precision instruments. They employ rotary geared motion — the most efficient and perfect method of transmitting mechanical motion. A choice of stainless steel movement or stainless steel with nylon bearings and pinion gear permits selection to meet specific requirements. Eight different Bourdon tube materials are available. Each Bourdon tube is "whip tested" at pulsating pressures approximately 50% higher than its pressure rating to insure calibration stability. Three case designs and materials and a complete range of dial sizes and pressures also provide for every individual need. Highest sustained accuracy and long service life are assured.

MAXWELL & MOORE, INC.

CONSOLIDATED ASHCROFT HANCOCK DIVISION

STRATFORD, CONNECTICUT

MAKERS OF 'AMERICAN' INDUSTRIAL INSTRUMENTS, 'ASHCROFT' GAUGES, 'CONSOLIDATED' SAFETY VALVES, 'AMERICAN-MICROSEN' INDUSTRIAL ELECTRONIC INSTRUMENTS, *Stratford, Conn.*, 'HANCOCK' VALVES, *Watertown, Mass.*, 'CONSOLIDATED' SAFETY RELIEF VALVES, *Tulsa, Okla.*, AIRCRAFT CONTROL PRODUCTS, *Danbury, Conn. and Inglewood, Calif.* "SHAW-BOX" AND 'LOAD LIFTER' HOISTS AND OTHER LIFTING SPECIALTIES, *Muskegon, Mich.* In Canada: Manning, Maxwell & Moore of Canada, Ltd., Galt, Ontario.

MAXWELL MANNING M&M MOORE INC. TRADE MARK

For more information circle **21** on inquiry card.

News

Great Britain's I.E.A. Exhibition Attracts 2700 Overseas Registrants

INSTRUMENTS PUBLISHING COMPANY, the only non-British exhibitor in the entire exposition, had many prominent visitors. Mr. O. B. Wilson, vice president of Minneapolis-Honeywell's Industrial Division is shown at left with John C. N. Hughes, London representative of Instruments Publishing Company.

VAST PROPORTIONS OF EXHIBITION show up on this picture. Integra, Leeds & Northrup's sign is in background.

FOXBORO (FOXBORO-YOXALL, LTD.) AND HONEYWELL are names that are as well known in England as in this country, although they are British companies.

LONDON, ENGLAND.—For the fourth time since 1951 (in the odd years) the British I.E.A. Show (Instrumentation, Electronics, Automation) was held at Olympia, May 7 through 16, 1957. It was sponsored by five of England's Manufacturers' Trade Associations, principally the British Industrial Measuring and Control Apparatus Manufacturers' (BIMCAM), the Scientific Instrument Manufacturers' Association of Great Britain, (SIMA), and the British Electrical and Allied Manufacturers' Association; also the British Lampblown Scientific Glassware Manufacturers' Association, and the Drawing Office Material Manufacturers' and Dealers' Association.

Chairman of the Organizing Committee was Foxboro-Yoxall's L. S. Yoxall. Concurrently, a conference was held for seven days, each day of which was devoted to a special subject and so designated—viz., Automation, Nuclear, Education, Medical, Industrial, Computer, and Communications and Navigation Day.

The final count showed attendance of 53,084 people (more than twice the previous record set in 1953), including 2700 overseas registrants from nearly 70 countries. Noted was the 28-man Soviet delegation. Five countries were represented by over 100 visitors each—the United States and Canada were not far behind.

More than 200 British exhibitors occupied booths which covered more than 200,000 sq ft. The encouraging figures prompted an Exhibitors' meeting on the last day to vote to throw next year's exhibition open to participants from abroad, and to hold an international event at Olympia, April 16 through 25, 1958 with the ambitious aim "of establishing Great Britain once and for all as the instruments and electronics centre of the world."

On "Computer Day" of the conference, Sir Walter Puckey, well known also in this country as an automation authority (who also visited last year's Automation Exposition in New York), spoke on the "Electronic Office." He compared the more than 4000 digital computers installed in the United States to Britain's fifty, and warned of West Germany's great strides in this field.

On "Medical Day," papers on Instrumentation in Medicine, The Artificial Heart-Lung, and Electronic Instruments for Clinical Testing with Radio-Active Isotopes were read.

James Emmet, Jr.

Mr. James Emmet, Jr., 50, vice president of Jas. P. Marsh Corporation died suddenly of a heart attack on the way home from a business trip.

Irving W. Reynolds

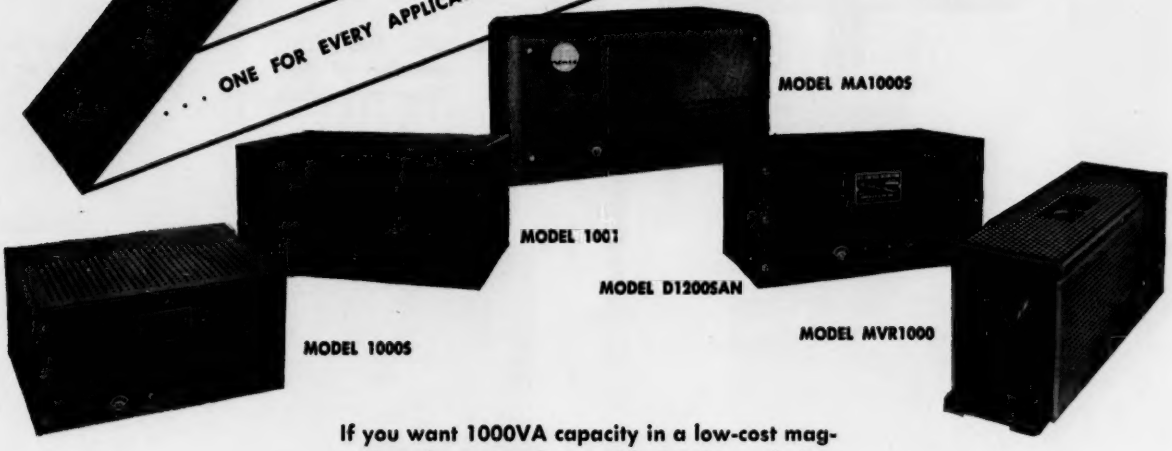
Mr. Irving W. Reynolds, 77, vice president of The Foxboro Company died June 3, in Foxboro. Mr. Reynolds was one of the first to join the company in 1908, the year when it was founded.

John Worley

John Worley Jewel Co. regretfully announces the demise on April 25 of John Worley, founder of the company.

NOW SIX 1000 VA REGULA*

. . . ONE FOR EVERY APPLICATION — ANOTHER EXAMPLE OF SORENSEN'S VERSATILITY



If you want 1000VA capacity in a low-cost magnetic voltage regulator with 0.5% regulation, choose the new, economical and compact MVR1000. If you need 1000VA but with 0.01% regulation, choose Model 1001. For *any* requirement, *any* application, Sorensen has exactly the right 1000VA unit . . . standard models meeting *special* requirements.

Sorensen offers you the widest possible range of characteristics — and a complete line which includes AC regulators, DC supplies, frequency changers, tubeless regulators and supplies, high voltage supplies, and meter calibrators. For research and industry, call on Sorensen — *the authority on controlled power.*

MODEL 1000S — Automatic wide-range electronic regulation with the original Sorensen frequency insensitive circuit incorporating the safety diode. Regulation ±0.1%.

MODEL MA1000S — For unattended installations requiring extremely dependable automatic line regulation. This tubeless unit offers stable long-life performance with minimum maintenance. Regulation ±0.5% over wide frequency range.

MODEL 1001 — Developed from unique, dependable Sorensen regulating circuit, refined for ultra-precise ±0.01% regulation.

MODEL D1200SAN — ±0.25% regulation for 400 cycle industrial and aircraft requirements up to 1200VA.

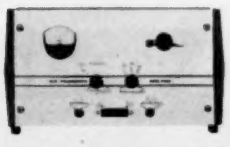
MODEL MVR1000 — New low cost compact magnetic voltage regulator for less exacting applications. Fully automatic ±0.5% regulation with fast response time.

*plus TWO new 1000VA regulated Frequency Changers . . . *write for details!*

SEND FOR CONDENSED CATALOG

NEW

APR1010



Three regulators in one — RMS, average and peak regulation, plus five sensing arrangements!

SORENSEN & COMPANY, 375 FAIRFIELD AVENUE, STAMFORD, CONN.

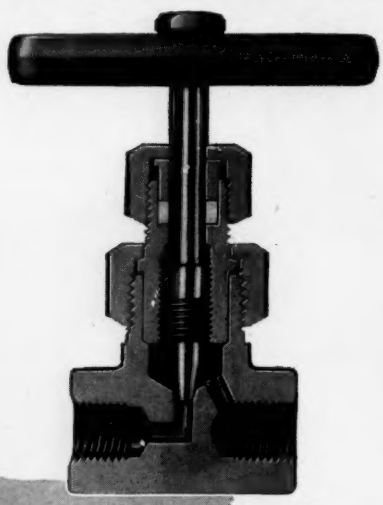
In Europe, contact Sorensen-Ardag, Eichstrasse 29, Zurich, Switzerland, for all products including 50 cycle, 220 volt equipment.

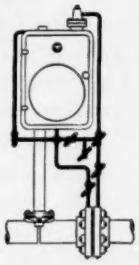
For more information circle **22** on inquiry card.

For corrosive field service...

AMERICAN®

Needle Valves





Teflon-packed, forged steel American® Needle Valves stand up in the toughest meter manifold jobs and other corrosive field services without gland leaks. Stainless or carbon steel precision machined valve bodies are specially suited for welding. Stainless steel centerless-ground valve stems are designed so that the valve can be repacked under pressure.

Standard valves design rated for pressures to 5,000 psi at 70°F. For pressures to 10,000 psi, upon request, valves are hydrostatically tested and individually inspected. Valves are furnished with graphite-impregnated asbestos packing for temperatures above 450°F.

Angle or straight patterns —screwed or union bonnets.

Consult your American Meter representative for full details.

AMERICAN METER COMPANY

GENERAL SALES OFFICE: Somerton, Philadelphia 16, Penna. • Albany Alhambra • Atlanta • Baltimore • Birmingham • Boston • Chicago Dallas • Denver • Erie • Houston • Kansas City • Los Angeles • Minneapolis • New York • Omaha • Pittsburgh • San Francisco • Seattle Tulsa • Wynnewood. IN CANADA: Canadian Meter Company, Ltd., Milton, Ontario • Calgary • Edmonton • Regina

SUPPLIERS TO THE GAS INDUSTRY for Ironcase, Tinned Steelcase, Aluminumcase and Welded Steelcase Meters • American-Westcott Orifice Meters Instruments • Reliance Regulators • Apparatus • Valves

For more information circle **23** on inquiry card.

Fluid Controls Institute Holds Spring Meeting

WHITE SULPHUR SPRINGS, W. VA.—The Fluid Controls Institute Inc. (formerly: National Steam Specialty Club) held its annual Spring Meeting at White Sulphur Springs and elected the following officers for the coming year: President—John S. Leslie, Leslie Co.;

John S. Leslie, Leslie Co., president of Fluid Controls Institute

vice president—Dean E. Madden, A. W. Cash Valve Mfg. Corp.; vice president—Marshall B. Taft, Minneapolis-Honeywell Valve Div.; treasurer—Paul K. Rogers, Jr., Skinner Chuck Co.; secretary—Edward J. Glinske, Jr., Cochrane Corp. Sixty members and guests were present. The group picture reflects the informal atmosphere which surrounded the committee reports and a panel discussion.

DDA Council Formed

SAN DIEGO, CALIF.—Formal incorporation of the DDA Council, Inc. has been announced by the new group's chairman, Stanley Rogers of Convair, San Diego. After a series of informal meetings in the Southern California area the Council will now aim at organizing chapters in various parts of the country. The first eastern meeting was held in New York in June. Close cooperation with the Simulation Council will be sought. Other Directors of the Council are: *Max Palevsky*, Packard-Bell Computer Corp.; *R. G. Selfridge*, Naval Ordnance Test Station, China Lake; *V. A. van Praag*, Bendix Computer; and *Allan L. Wolff*, Litton Industries. Address *Stanley Rogers*, 3023 Alcott St., San Diego 6, Cal. for further details.

SALES MANAGERS: You route this memo—

to your ad department and agency—reminding them to plan now to advertise in the 1958 I&A Handbook & Buyers' Guide

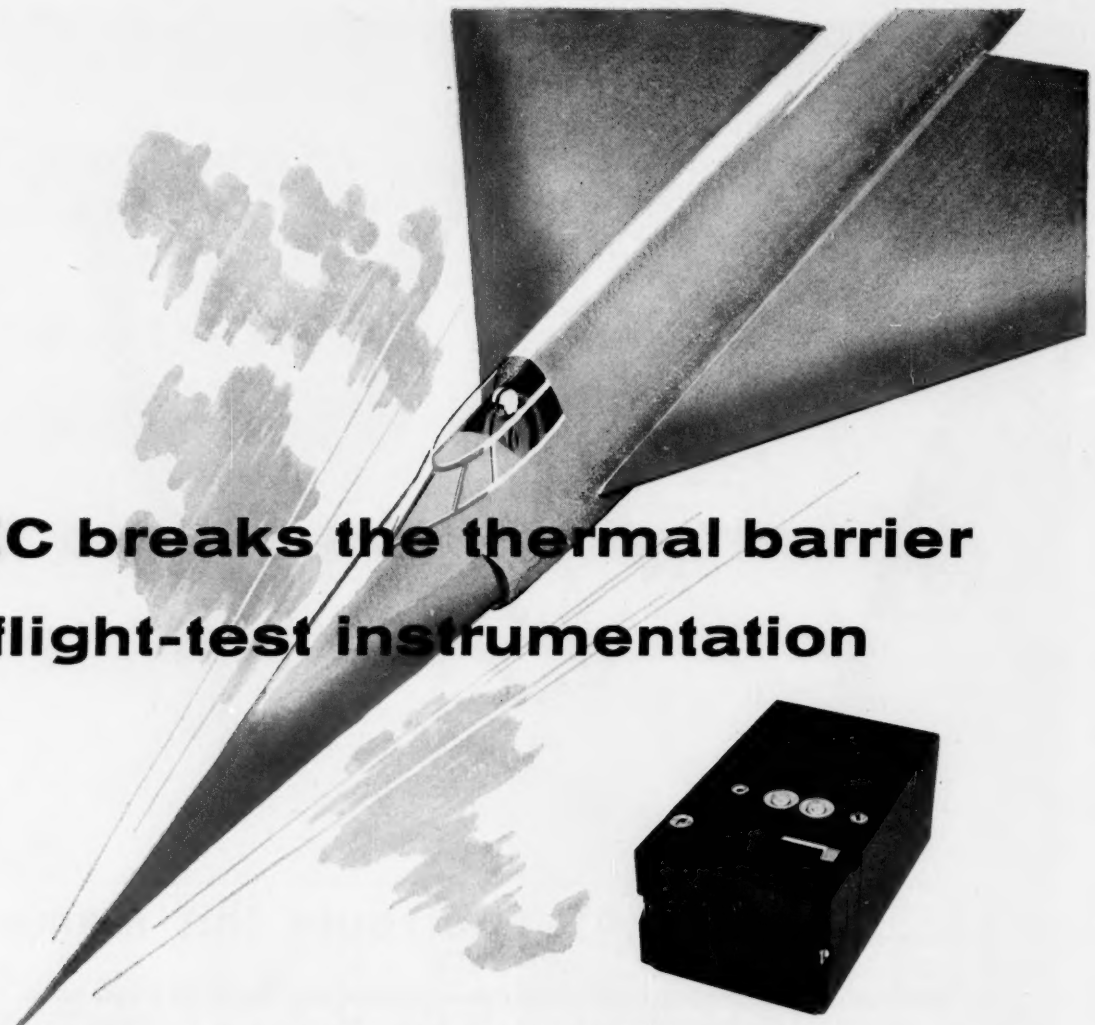
Industry's only instrument-control equipment buying directory, the Guide offers you . . .

- Entree to 23,000 buyers of instrument and automatic control equipment.
- A directory listing equipment, names and addresses of 3,000 manufacturers.
- Twenty-two years experience selling to OEM and end users.
- Year 'round contact with industry's big buyers.

Reserve your ad space now. Forms close August 15-31—write:

INSTRUMENTS PUBLISHING CO., INC.
845 Ridge Ave., Pittsburgh 12, Pa., FAirfax 1-0161

For more information circle **60** on inquiry card.



CEC breaks the thermal barrier in flight-test instrumentation

—with a new high-temperature oscillograph

A significant *first* in oscillograph recording, CEC's unique 5-122 operates in a temperature range of −65°F to +250°F at altitudes to 120,000 feet. Twenty-six channels (plus two static reference traces) can be recorded at writing speeds in excess of 12,000 inches per second. The 5-122 also meets the challenge of minimum size, consists of three small, separate modules—oscillograph and magazine, master timing unit, and control unit. Both the control and master timing units can be installed in remote locations.

Other features include new jump-speed selection method, flash timing, and improved automatic record identification systems; explosion-proofing in accordance with military specifications: crash-resistant magazine; and provisions for synchronizing the 5-122 into an over-all data accumulation system. Compact size is 11″ wide by 8″ high by 18½″ long. Weighs 80 lbs. fully loaded, 55 lbs. without magazine. Power requirements: 200 volts, 400 cycle, 3 phase. Contact your nearby CEC field office, or write for Bulletin CEC 1585-X1.

—and 7 new high-temperature galvanometers

Another important *first* in flight-test recording is CEC's new family of High-Temperature Galvanometers. Accuracy is guaranteed in ambient temperatures to 250°F for extended periods with a flat response from 0 to 3000 cps. Contact your CEC field office, or write for Bulletin CEC 1528-X7.

Consolidated Electrodynamics

300 North Sierra Madre Villa, Pasadena, California

OFFICES IN PRINCIPAL CITIES THROUGHOUT THE WORLD

For more information circle **24** on inquiry card.

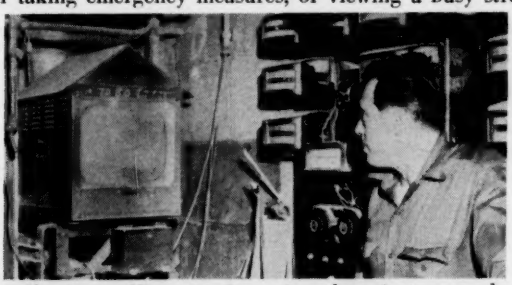
Pittsburgh Pioneers in High-School Education

PITTSBURGH, PA.—Pittsburgh, Pa. is pioneering with three experiments in high-school education, all of which are attracting national attention. (1) Twenty-eight classes in twenty-three different schools are being given 20-minute TV lessons by expert teachers, with followup by classroom teacher. (2) In an experiment in "master teaching," Dr. Harvey White, Professor of Physics at U. of Calif., one of the country's outstanding teachers in physics, is giving an open-circuit-TV introductory course in physics. The live transmissions are being received in high-school physics classes throughout Pittsburgh, and the transmissions are being photographed for future use. (3) The first high-school course in automation and instrumentation will be given to a select group of science-math senior high-school students starting Sept., 1957; readers of *I&A* will be kept informed of all details of this plan.

Funds with which to finance the indoctrination of the teaching staff for the course in instrumentation-automation are being sought by the Committee of Consultants advising the school board on this project. Contributions are being solicited from instrument manufacturers, societies, and individuals in the instrument field. Send contributions to "Pittsburgh Board of Education," Administration Bldg., Forbes and Bellefield Ave., Pittsburgh 13, Penna.; attention C. Hoffmaster, Automation course. All contributors will be listed in a future review of progress in this pioneering high-school course in instrumentation.

New ITV Applications

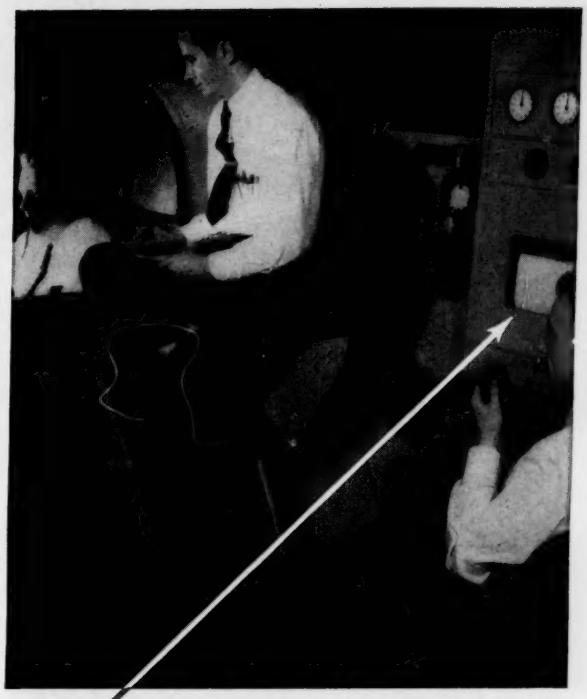
PITTSBURGH, PA.—Observing a meter from a remote location to accomplish savings, or a hazardous area for taking emergency measures, or viewing a busy street



for effective traffic control, are just three instances where ITV is expanding into new fields.

Picture above shows an engineer watching electric power company's demand meter, located 500 feet away, in order to control power consumption to avoid peak demands. As the power company does not permit tappings onto the demand meter located in its sub-station for remote indication, a $4000 investment in ITV will save the user $10,000 a year. Another General Precision Lab.'s ITV set-up is in Esso's propane deasphalting pilot unit where foreman watches hazardous area from his safe office, 300 feet away.

At a recent IEE-meeting in Pittsburgh a speaker from GE suggested use of "slow-scan" technique in ITV for observing busy city intersections from a coordinator's office for radio control of traffic signals. "Slow-scan" permits transmission of an image over telephone lines every 4 or 5 seconds in contrast to customary 30 per second.



BRISTOL CHART (near instructor's head) plots deviation from intercept course on Link flight simulator.

Famous Link Trainers check out student pilots with special Bristol Recorder charts

Errant student pilots call these special Bristol recorder charts "stool pigeons."

Used on the renowned aviation trainers made by Link Aviation, Inc., Binghamton, N. Y., Bristol charts not only "tell all"—they make a written performance record for benefit of instructor and student, graphing such quantities as deviation from course, heading, etc.

This is just one of hundreds of applications for Bristol special charts. They're in use by the hundreds in science, engineering and industry for applications ranging from multiple channel printers and recorders to computer function plotters.

Naturally, Bristol special charts draw on our 68 years of experience in chart printing for our own Bristol instruments. Our recently expanded chart printing facilities can handle strip charts up to 29⅝ inches across; circular charts to 12 inches diameter.

Some of the many papers available include: highest quality regular chart paper in standard thicknesses; wax-coated, heat-sensitive, chemically-coated, electrically-sensitive or pressure-sensitive papers; papers for metallic marking; foil-type laminates for extreme dimensional stability; card stock; carbon-coated (or smoked) papers. We can handle special punchings or printing to any mathematical law.

Write for complete information on the Bristol chart service. The Bristol Company, 154 Bristol Road, Waterbury 20, Connecticut. 7.22

BRISTOL TRAIL-BLAZERS IN PROCESS AUTOMATION

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

For more information circle **25** on inquiry card.

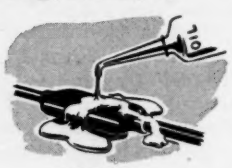
Partners in Production

Joy Electrical Connectors and Automatic Controls

What happens to Automation... when electrical connectors fail?

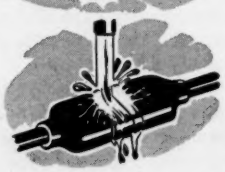
No automatic control system yet devised will keep machines running when an electrical plug or receptacle in their power feeder line or power control circuit *poops out.* That's why JOY's one-piece molded Neoprene connectors deserve your careful consideration. Factory wired and permanently molded to cord or cable, they provide many extra advantages that add up to a long life of dependable service under the most adverse operating conditions. (A few are listed below.) Available in a wide variety of designs with 1 through 16 contacts for 150 to 600 volt applications. ***Joy Manufacturing Company, Electrical Products Div., 1201 Macklind Ave., St. Louis 10, Mo. Executive Offices, Henry W. Oliver Bldg., Pitts. 22, Pa.***

Oil-Sealed . . .
One-piece molded cable connector assembly protects conductors from oil and other external impurities. Face rings protect contacts from similar contamination, when connectors are engaged.



Distortion-Proof . . .
Factory molded as trim one-piece synthetic rubber jacketed units, JOY connectors cannot crack, will not shatter and are practically impossible to knock out of shape.

Moisture-Tight
JOY electrical connectors are absolutely moisture-tight from wiring juncture to face . . . and when connected even their contacts are protectively encased in a resilient housing.



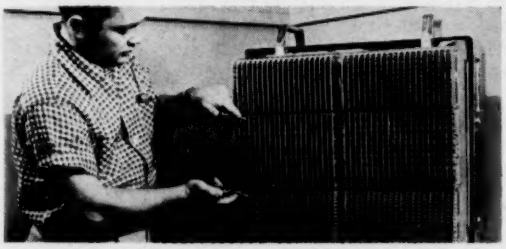
CD 355.2

JOY
SOURCE OF INDUSTRY'S FAVORITE ELECTRICAL CONNECTORS SINCE '28

For more information circle **26** on inquiry card.

Midget Computer

DOWNEY, CALIF.—RECOMP, a transportable, midget computer that can add, subtract, multiply and divide 1,000 times faster than the familiar desk calculator, has been designed and developed by AUTONETICS, a division of North American Aviation, Inc.



The first model of this general-purpose, all-transistor digital computer, designated CP-266, has been produced and delivered to the U. S. Air Force, Rome Air Development Center.

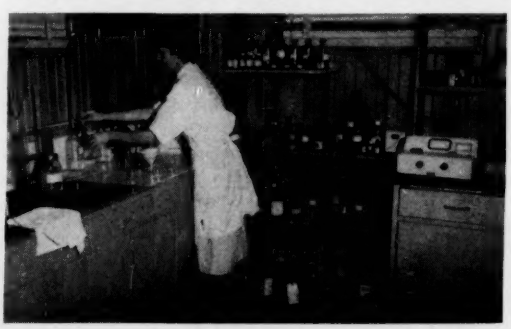
Ready to work when plugged in, it operates on less current than an electric toaster. The unit's circuitry consists of small, etched-circuit plug-in boards of relatively few standard types. It has no vacuum tubes.

Spectra Data Check

PITTSBURGH, PA.—The Coblentz Society's Committee on Infrared Absorption Spectra is sending questionnaires to its members to assert information on work done in connection with the infrared reference spectra and sorting techniques used, in order to achieve a greater rate of publication of reference data. For further data contact Mrs. Clara D. Smith, Battelle Memorial Institute, 505 King Ave., Columbus, Ohio.

News Bits

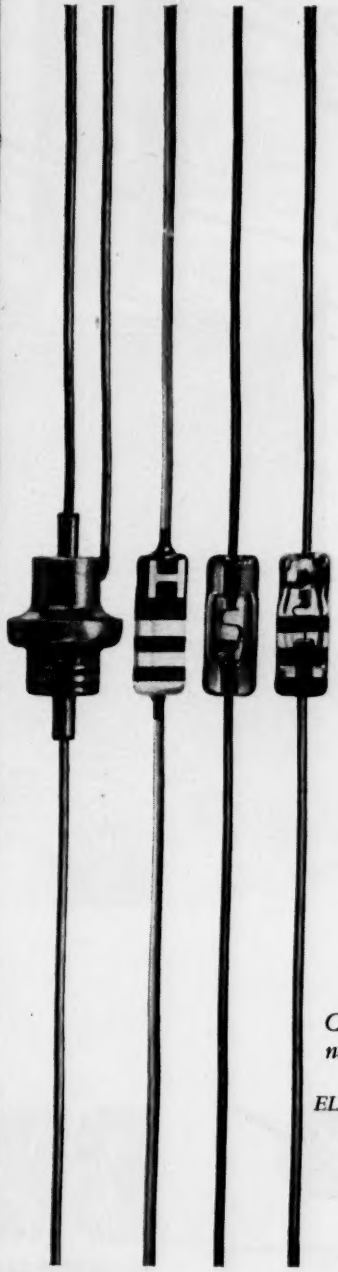
BAUSCH & LOMB supplied a Spectronic 20 Colorimeter (a combination colorimeter and spectrophotometer) to the Western Company of Midland, Texas, which enables the firm to make sulfate content analyses of oil



field brine or acid for its customers within half an hour, a procedure which previously took 6 hours. Picture shows the simple laboratory setup.

RADIATION INC. reports important advancements in the field of telemetry and data reduction: (1) A new high-speed analog-to-digital processing system is capable of receiving 24,000 data samples per second. Telemetered information is received in a form which is immediately

HUGHES
SEMICONDUCTORS
First of all, for reliability



RELIABILITY

WHAT IT IS. At Hughes, reliability is the probability that a device will give satisfactory performance during a specific period of time when used in the manner intended. And at Hughes, the probability is high, approaching certainty.

HOW HUGHES ACHIEVES IT. With meticulous consideration to every detail, Hughes has accumulated extensive knowledge of the semiconductor art, extensive knowledge of all the subtle and delicate, yet critical, factors involved. To *really* know is essential. Then, and only then, reliability becomes an automatic result—built into every unit.

HOW HUGHES MAINTAINS IT. Hughes Quality Control is the "watchdog," checking and rechecking every phase of production on a carefully regulated statistical basis. This extensive effort ensures prompt discovery of any variation which might affect the ultimate quality—and the *reliability*.

HOW YOU OBTAIN IT. Specify Hughes, for the greatest possible assurance. For additional information, please write:

SEMICONDUCTOR DIVISION
HUGHES PRODUCTS
International Airport Station, Los Angeles 45, California

Creating a new world with ELECTRONICS

HUGHES PRODUCTS

HUGHES
SEMICONDUCTORS

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BREEZE BELLOWS WIN

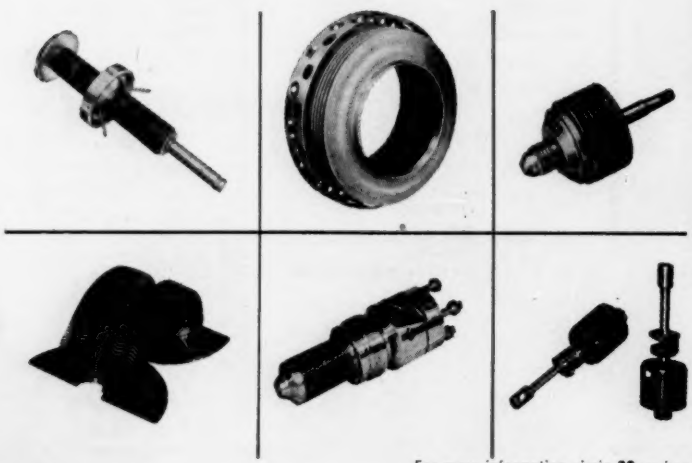
the tough game of high performance

Breeze bellows engineers work in that challenging area where ready-made designs won't do the job. Every project is a custom project, engineered specifically for each problem application.

We have a wealth of experience with all weldable alloys such as Inconel X, titanium, Ni-Span, Hastelloys, Stainless 300 and 400 steels.

We are solving critical problems in instrumentation, fuel regulation, pressure switches and expansion joints, hot air ducting, pressure surge tanks, packless valves, expansion and vibration joints, oscillating and rotating shaft seals, atomic and nuclear reactors.

Breeze invites your inquiries on bellows jobs *beyond the routine* . . . for the most exacting requirements.



BREEZE

CORPORATIONS, INC.

700 Liberty Avenue, Union, N. J.

BREEZE MARK

For more information circle **28** on inquiry card.

readable. Accuracies of ± 0.4% can be obtained.—(2) An "electronic computer output printer" will record output of electronic computers at the rate of one million characters per minute.

WEBBER GAGE CO. suffered a $110,000 loss when fire recently swept its plant. Damage to precision machine tools and instruments was the heaviest. The building was damaged to an estimated extent of $10,000.

ROCKFELLER INSTITUTE reports that its scientists have developed a new instrument which combines color-television and ultraviolet-microscope techniques to study structure of cells in the living state, as well as their chemical composition. This ultraviolet, color-translating television microscope, or UCTM, avoids modification of the cells which previously was necessary to make the structures more visible, or exposure to streams of electrons (as in the electron microscope) with the danger of destroying them.

STANFORD RESEARCH INSTITUTE, Calif., reports that in 1956 research was carried out on 760 different projects, more than half of which were commercially sponsored, for a total of $12.6 million, 25% above 1955. Work included machine reading of printed characters, upper-atmosphere radio-wave reflection, freight-car distribution, high-temperature electron tubes, air pollution, etc.

MINIATURE PRECISION BEARINGS received a framed original water color of its plant as award by *Factory Management & Maintenance* magazine for being one of the "Ten Best Plants" constructed during 1956. **LEEDS & NORTHRUP'S** new plant at North Wales, Penna., was also selected as one of the award winners.

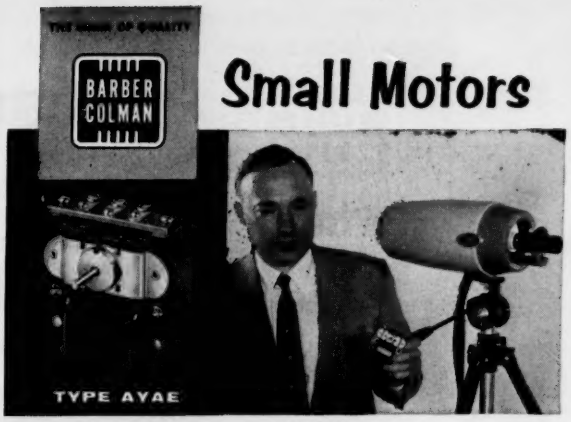
Stock Report

Any further information concerning any of the following issues may be obtained from the Research Department, Bache & Co., 36 Wall Street, New York 5, N. Y.

New York Stock Exchange:

	Price Range For 1957 Thru June 17th		
	High	Low	Price As of June 17th
ACF Industries	60 3/4	60	60 1/2
Aeroquip Corp.	27 1/8	26 3/4	27
Allis Chalmers	34 3/8	33 7/8	34 3/8
American Chain & Cable	59 1/4	58 1/4	59 1/4
American Machine & Foundry	38 7/8	38 1/2	38 1/2
American Machine & Metals	55 1/4	54	55 1/4
American Optical	35 7/8	35 3/4	35 3/4
American Tel. & Tel.	176 3/4	176 1/2	176 5/8
Beckman Instruments	40 1/4	39 1/2	40
Bell & Howell	39 7/8	39 1/4	39 7/8
Bendix Aviation	60 7/8	60 1/8	60 1/8
Boeing Airplane	45	43 5/8	43 3/4
Bullard	21 3/4	21 3/4	21 3/4
Bulova Watch	18 1/2	18 1/2	18 1/2
Burroughs	47 1/2	46 7/8	47 1/4
Carborundum	50 1/4	49 3/8	49 3/8
Cincinnati Milling Machine	42	41 3/4	41 3/4
Clevite	21 1/8	20 3/4	20 3/4
Columbia Broadcasting 'A'	32 1/2	31 3/4	31 7/8
Consolidated Electronics	32 5/8	31 5/8	31 5/8
Cornell Dubilier	22 1/8	21 3/8	21 3/8
Corning Glass	95 7/8	94 1/4	94 1/4
Curtiss-Wright	41 7/8	40 5/8	41
Cutler Hammer	61 3/4	61 1/2	61 1/2
Consolidated Electrodynamics	49 3/4	48 3/4	49 3/4
Daystrom	40 1/8	39 7/8	40
Dobeckmun	44	38 1/4	42 1/2
Douglas Aircraft	77 1/2	75 5/8	75 3/4
Eastman Kodak	108 1/2	107	107 3/4
Eaton Mfg.	56 1/2	56 1/2	56 1/2
Electric Auto Lite	38 1/4	37 3/4	37 3/4
Elgin Watch	11 3/4	11 3/4	11 3/4
Emerson Electric	30	29 5/8	29 5/8
Food Machinery & Chemical	62 7/8	62 1/4	62 3/4
Gamewell	29	29	29
Garrett	43 1/4	42 1/4	42 1/4
General Dynamics	60 1/4	58 1/2	58 5/8
General Electric	70	69 1/4	69 7/8
General Instrument	7 1/8	7	7 1/8
General Mills	61 3/4	61 1/2	61 1/2
General Precision Equipment	43 1/8	42	43
General Railway Signal	32	31 3/4	31 3/4
General Telephone	42 7/8	42 1/4	42 5/8

Continued on page 1256



"We needed compact, reversible motors to drive TV camera iris and focus mechanisms."

R. A. White, General Precision Laboratory Incorporated
Pleasantville, New York

The GPL Remote Iris and Focus Television Camera shown above may be operated as far as 500 feet from control location. To drive the lens focus mechanism and the iris control, General Precision Laboratory selected Barber-Colman AYAE high-torque, fast-reversing small motors featuring low-inertia rotors. For accurate actuation of your products, too, there is a wide selection of Barber-Colman motors up to 1/20 hp. Unidirectional, synchronous, and reversible . . . with or without gearing . . . open or enclosed. Write for Catalog F-4271, or see Sweet's Product Design File.

BARBER-COLMAN COMPANY
Dept. S, 1215 Rock Street, Rockford, Illinois
For more information circle **29** on inquiry card.

DEHYDRATION
OF GASES
HI-LO PRESSURES
HI-LO FLOWS
"PAT. PEND."

- New Leakproof Design — Chambers and Cartridges "O" Ring sealed, no possibility of gas bypassing the cartridge.
- No tools required to change cartride or Mechanical Filter Element for cleaning.
- Manual or Automatic Units. Portable, stationary or airborne installations.

ROBBINS AVIATION
WRITE FOR BULLETIN
1735 W. FLORENCE AVE. LOS ANGELES 47, CALIF.

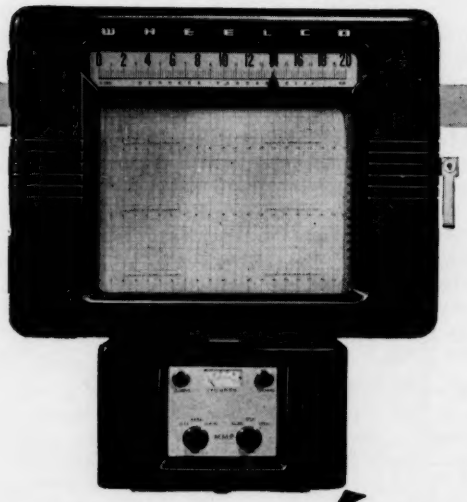
For more information circle **30** on inquiry card.

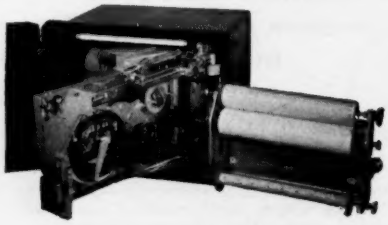
THE MARK OF QUALITY

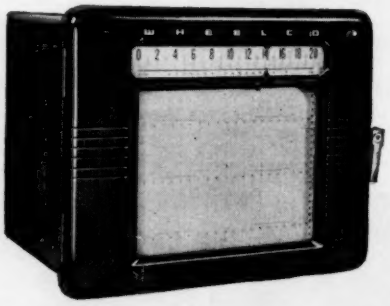
BARBER COLMAN

Wheelco Instruments

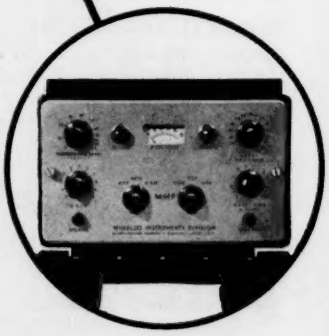
Insure uniformity







Automatic Reset for Recording Controllers — available with Series 8000 instruments for demanding processes where small capacitance requires wide proportional settings and where offset cannot be tolerated. Tamperproof cover protects all adjustments, leaves controls available to operator.



Series 8000 Recorders and Recording Controllers — available in a wide range of models, these self-contained null-balancing electronic instruments feature convenient swing-out design for easy chart and instrument maintenance. *Multi-point recorders* keep permanent records of up to 16 points on a single chart . . . feature up to six limit switches for high and/or low signal indications . . . single- or multi-color printing . . . 3 to 24 in. per hr recording speeds.

The instruments shown on these pages are only representative of the many models featuring advance design and precision engineering developed through Barber-Colman's years of experience, serving practically every industry using measurement and control.

Here is one wholly dependable source on which you can standardize for the accuracy you need in precisely the form best suited to every given process. Whether you need a single instrument or a control center, you just identify your process to your broadly experienced Wheelco engineer. He recommends simpler, lower cost instruments where accuracy and uniformity are less critical, offers custom-engineered control forms to meet special requirements. You are assured of unsurpassed accuracy of control for precision processes.

High-quality materials and rugged construction, use of plug-in components wherever possible, special accessibility features, and large easy-to-read indicators are other "plusses." Specify Wheelco for a *new measure* of reliability, economy, and convenience.

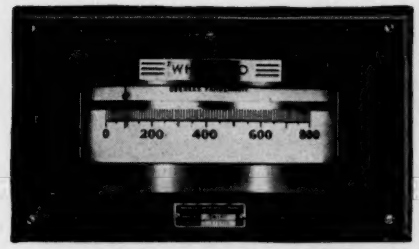
For more information circle **31** on inquiry card.

# of process control

with accurate, reliable, trouble-free WHEELCO recorders, controllers, indicators, accessories, or complete control centers

Wheelco Capacitrols — completely self-contained direct-deflection-type electronic indicating controllers. Sensitive no-drift control appropriate to a variety of processes is assured by range of models, available both in vertical 400 Series (left) and in horizontal "Panelmount" types (above). Available in a variety of control forms, such as time-proportioning, two-position, Multronic, proportional-position, and electrical-proportioning. Both styles available as Limitrols — with built-in automatic shutoff.

Series 150 Amplitrols — potentiometer-type controllers — offer precise control of batch-type heating at minimum cost. Model 151 is on-off controller, Model 152 provides anticipatory, time-proportioning control. The electronic circuit has been designed to "fail safe" in event of failure of any integral part.



Indicating Pyrometers — built to highest standards for precision instruments . . . feature meter movement with Alnico V magnet and electrical compensators for resistance changes in the metering system.

Packaged Control Centers, like the one shown on the right, are designed and manufactured by Wheelco to meet industry's control needs precisely and economically. A prewired, prefabricated Wheelco control center saves you money by simplifying installation and incorporates your instruments and accessories for convenient and efficient use in an attractive panel board or heavy steel cabinet. Discuss this important modern approach to instrumentation with your nearby Wheelco field engineer!

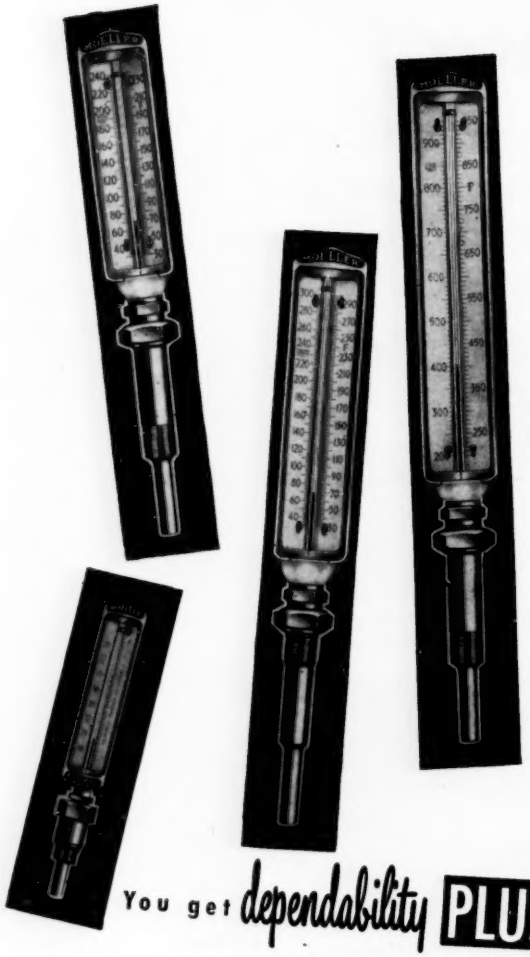
BARBER-COLMAN COMPANY

Dept. S, 1515 Rock Street, Rockford, Illinois, U.S.A.

BARBER-COLMAN of CANADA, Ltd., Dept. S, Toronto and Montreal, Canada

Industrial Instruments • Automatic Controls • Air Distribution Products • Aircraft Controls • Electrical Components
Small Motors • Overdoors and Operators • Molded Products • Metal Cutting Tools • Machine Tools • Textile Machinery

For more information circle **31** on inquiry card.



You get dependability PLUS in Moeller Industrial Thermometers

because our business has been the design and manufacture of temperature measuring instruments since 1867.

Moeller Industrial Thermometers are made in any form—straight angle, right or left side angles, reclined or inclined angles, in scale ranges of —120°F to plus 1125°F or in centigrade equivalents. Available in 5", 7", 9" and 12" scale sizes with plain stems, union connection stems and separable sockets in all stem lengths and alloys. *Mail the coupon today for detailed information.*

MOELLER INSTRUMENT COMPANY
132nd ST. and 89th AVE
RICHMOND HILL 18 N. Y.
Representatives in Principal Cities

Gentlemen: Without obligation, please send me Moeller Catalog No. 150 on Industrial Thermometers.

NAME .....
FIRM .....
ADDRESS .....
CITY ..... ZONE ..... STATE .....

For more information circle **32** on inquiry card.

New York Stock Exchange:

Continued from page 1253

General Time	22 5/8	22 1/2	22 1/2
General Tire & Rubber	87 1/4	85 5/8	86
International Business Machines	336	330	335
International Tel. & Tel.	36	35 3/4	35 7/8
Lockheed Aircraft	42 3/8	41 1/2	41 1/2
Magnavox	43 5/8	43 1/8	43 1/2
Minneapolis-Honeywell	107 1/2	106	107 1/2
Minnesota Mining & Mfg.	92	87	92
Motorola	47 7/8	47	47 7/8
National Acme	66	66	66
National Cash Register	68 1/8	67	67
North American Aviation	30 3/4	30	30 1/8
Northrop Aircraft	25	24 5/8	24 5/8
Otis Elevator	48 1/2	48	48 1/4
Philco	15 3/4	15 5/8	15 5/8
Radio Corp. of America	38 3/8	38	38
Raytheon	21	20 3/4	20 3/4
Rheem Mfg.	18	17 3/4	17 3/4
Robertshaw Fulton	30 7/8	30 1/2	30 1/2
Sangamo Electric	38 1/4	38	37 1/2-38 1/4(1)
Sperry Rand	23 7/8	23 3/8	23 1/2
Square D	32 7/8	32 3/8	32 1/2
Standard Coil Products	7 5/8	7 5/8	7 5/8
Starrett (L.S.)	82 1/4	82 1/4	82 1/4
Stewart-Warner	37 1/2	36 1/8	37 1/2
Sylvania Electric	41 7/8	41 1/4	41 5/8
Teletype	5 3/8	5 1/4	5 1/4
Texas Instruments	28 3/8	27 1/4	28 1/8
Thompson Products	77 1/8	76 5/8	77
Tung-Sol Electric	36 7/8	35 7/8	36
Underwood Corp.	32 1/4	31 3/8	32
Union Carbide & Carbon	123 3/4	121 1/4	123 3/4
Western Union	19 3/8	19 1/8	19 1/4
Westinghouse Air Brake	30 3/8	30	30 3/8
Westinghouse Electric	66 1/4	64 5/8	66 1/4
Worthington Corp.	65 3/4	64 1/2	65

(1) Not Traded - Bid - Asked

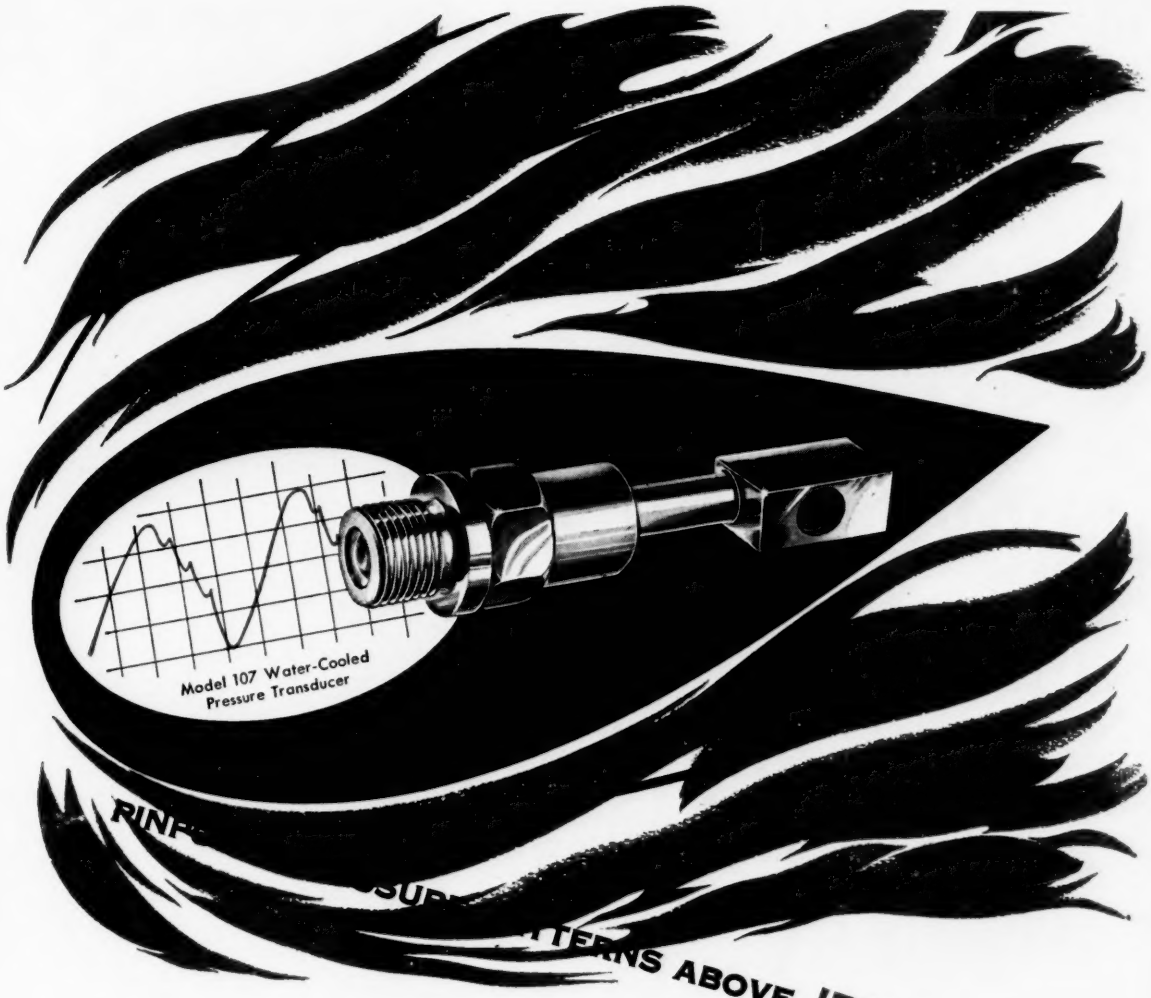
American Stock Exchange:

	Price Range for 1957 to June 17th		
	High	Low	Price As of June 17th
Americas Meter	32 1/4	32 1/4	32 1/4
Arc Equipment	22 7/8	22 5/8	22 3/4
Belock Instrument	10 7/8	10 1/2	10 1/2
Bearns Watch	7	7	7 1/8 - 7 3/8 (1)
Breese Corp.	7 1/2	7 1/2	7 1/4 - 7 1/2 (1)
Barry Controls	12 3/4	12	12 1/4
Clark Controller	26 1/2	26	26 - 26 1/2 (1)
Clarostat Mfg.	4 3/4	4 3/4	4 3/4
Clary Corp.	4 3/8	4 1/4	4 1/4
DuMont Laboratories	5 1/8	5	5
Dynamics Corp. of America	6 3/8	6 1/8	6 1/8
Electronics Corp. of America	9 3/4	9 1/2	9 3/4
El-Tronics	2 1/2	2 1/4	2 1/2
Electronic Communication	10 5/8	10 3/8	10 5/8
Fairchild Camera & Instrument	17	16	17
Globe-Union	19 1/4	19 1/4	19 1/4
Haseltine Corp.	39 1/4	38 5/8	38 1/4-38 3/4 (1)
International Resistance	5 1/4	5	5 1/4
Lear Inc.	7 1/8	6 5/8	7
Litton Industries	45 1/2	42 1/4	45 1/2
National Research	24	23 1/4	23 1/4
Neptune Meter	29 1/8	29	29
New Haven Clock	5/16	5/16	5/16
Norden-Ketay	11 5/8	11 3/8	11 3/8
Nuclear Corp. of America 'A'	2 1/8	2	2 1/8
Pneumatic Scale	24 1/8	24 1/8	23 3/4 - 24 1/2 (1)
Reliance Electric	47 3/8	47	47
Servo Co. of America	6	6	6
Servomechanisms	11 3/4	11 3/4	11 3/4
United Shoe Machinery	40 3/4	40 1/4	40 5/8
Wallace & Tiernan	28 3/4	28 1/2	28 1/2
Waltham Watch	2	1 7/8	1 5/8

(1) Not traded - Bid - Asked

Over-The-Counter:

	Quotation As Of June 14th	
	Bid	Asked
Aerovox Corp.	4 3/4	5 1/4
Aircraft Radio Corp.	21 3/4	22 3/4
Argus Corp.	-	18 3/4
Eitel-McCullough Co.	34	35
Electronics Associates	75	79
Elox Corp. of Michigan 'A'	8 3/8	8 7/8
Elox Corp. of Michigan 'B'	8 1/4	8 3/4
Erie Resistor Corp.	12 5/8	13
G. M. Giannini	18 3/4	19 3/4
Liquidometer Corp.	7 1/2	8 1/8
P. R. Mallory & Co.	48	50 1/2
W. L. Maxon	5 3/4	6 3/8
Penn Controls, Inc.	18	19
Speer Carbon, Inc.	29 3/4	31
Sprague Electric	31 1/4	33 1/4
Taylor Instrument	76	78 1/2
Telecomputing Corp.	4 1/4	4 1/2
Topp Industries	10 3/8	11 1/8
Varian Associates	15 7/8	16 3/4
Vitro Corp. of America	23 3/4	25 1/4



RINF... ...SUR... ...TERNS ABOVE 5000°F

Proven Design — new, high temperature pressure transducer uses same catenary diaphragm and tubular strain cylinder as NORWOOD CONTROLS' highly successful air-cooled models. Immune to external vibration; mounts flush with negligible change in volume of pressure chamber; extremely high frequency response, flat to 10,000 cps.

Withstands ultra-high temperatures — designed for use in rocket and jet engines, high temperature chemical reactions, etc. Efficient water-cooling system enables diaphragm to withstand gas temperatures above 5000°F. Heat transfer rate 11 BTU/sq. in./sec. with 85°F temperature rise of cooling water.

Corrosion resistant — All exposed parts of stainless steel, can safely be exposed to highly oxidizing conditions.

Full Scale Pressures — 0–1000 and 2000 psi ranges with 1% of full scale accuracy and excellent temperature compensation. (Other ranges available on request.)

Write for Data Sheet A157-2 on Model 107 and Data Sheet A257 covering Norwood Controls' air-cooled transducers, which have recently been substantially reduced in price.

COPYRIGHT 1957 DETROIT CONTROLS CORP.

NC CONTROLS

NORWOOD CONTROLS
UNIT OF DETROIT CONTROLS CORPORATION

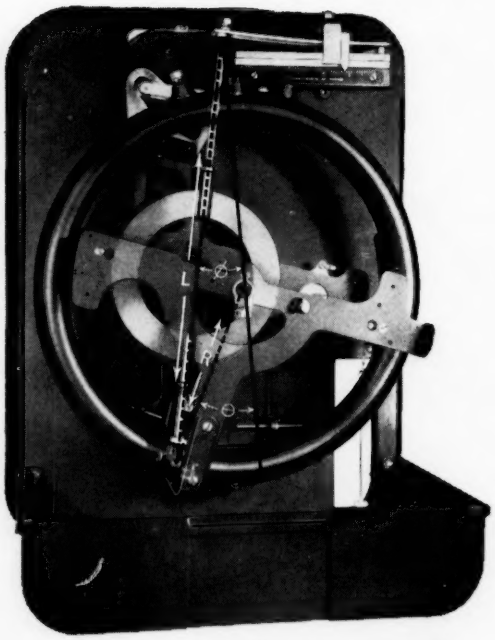
937 Washington Street, Norwood, Mass.

For more information circle **33** on inquiry card.

HAGAN RING BALANCE FEATURES — NO. 1

TRIGONOMETRY OF

UNIQUE RANGE CALIBRATION SYSTEM PROVIDES HIGH SENSITIVITY AT LOW FLOWS

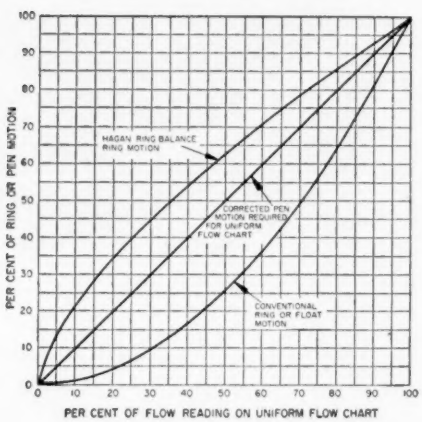


Push rod moves upward against range spring, governing ring rotation in accordance with the diagram below.

Low-flow sensitivity is a built-in feature of the Hagan Ring Balance flow meter. Rotation of the ring, in response to differential, is governed by the adjustable range spring in accordance with the unvarying trigonometry of the range calibration mechanism. This is expressed by the formula:

$$\text{Spring deflection} = R(1-\cos\theta) - L(1-\cos\phi),$$

and is graphically illustrated at the right. The upper curve shows that the ring motion at low range exceeds the requirement to produce pen motion linear with flow. Thus, the cam which transmits ring motion to the pen arm can convert this excess ring motion into extra power for precise pen movement.

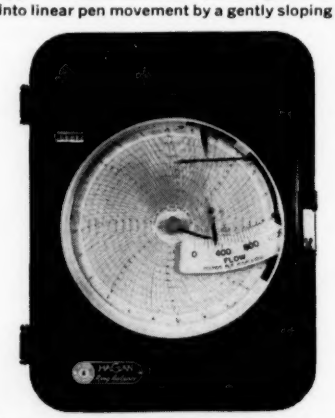


Excess motion of the Hagan ring, as shown by upper curve, is converted (with a gain in torque) into linear pen movement by a gently sloping cam.

METERING APPLICATIONS WHICH REQUIRE WIDE TURN-DOWN CALL FOR HAGAN RING BALANCE METERS. You get this feature when you specify Hagan, as well as the following:

1. Ease of calibration under operating static pressures with factory calibrated check weights! No more four-story water columns and telephones!
2. Safe operation with rings rated at 2,500, 10,000, 15,000 psig. No gaskets, no stuffing boxes.
3. Sealing fluid density and level not critical. No eyedroppers required.
4. Interchangeable ring assemblies for full scale ranges from 0.5″ w.c. to 560″ w.c. Adjustment on any one ring over a 7:1 differential range.
5. Wide range computation and/or compensation by means of built-in, easily checked mechanisms available on most models.
6. Pneumatic or electric transmission also available.

Bulletin MSP-141 describes these features and the new design of the Hagan Ring Balance meter case. ASK US FOR IT.



New, rigid, weatherproof, die-cast, aluminum case. Four-piece back for complete accessibility.

HAGAN CHEMICALS & CONTROLS, INC.

HAGAN BUILDING, PITTSBURGH 30, PENNSYLVANIA
DIVISIONS: CALGON COMPANY · HALL LABORATORIES

For more information circle **34** on inquiry card.

FACTS

about

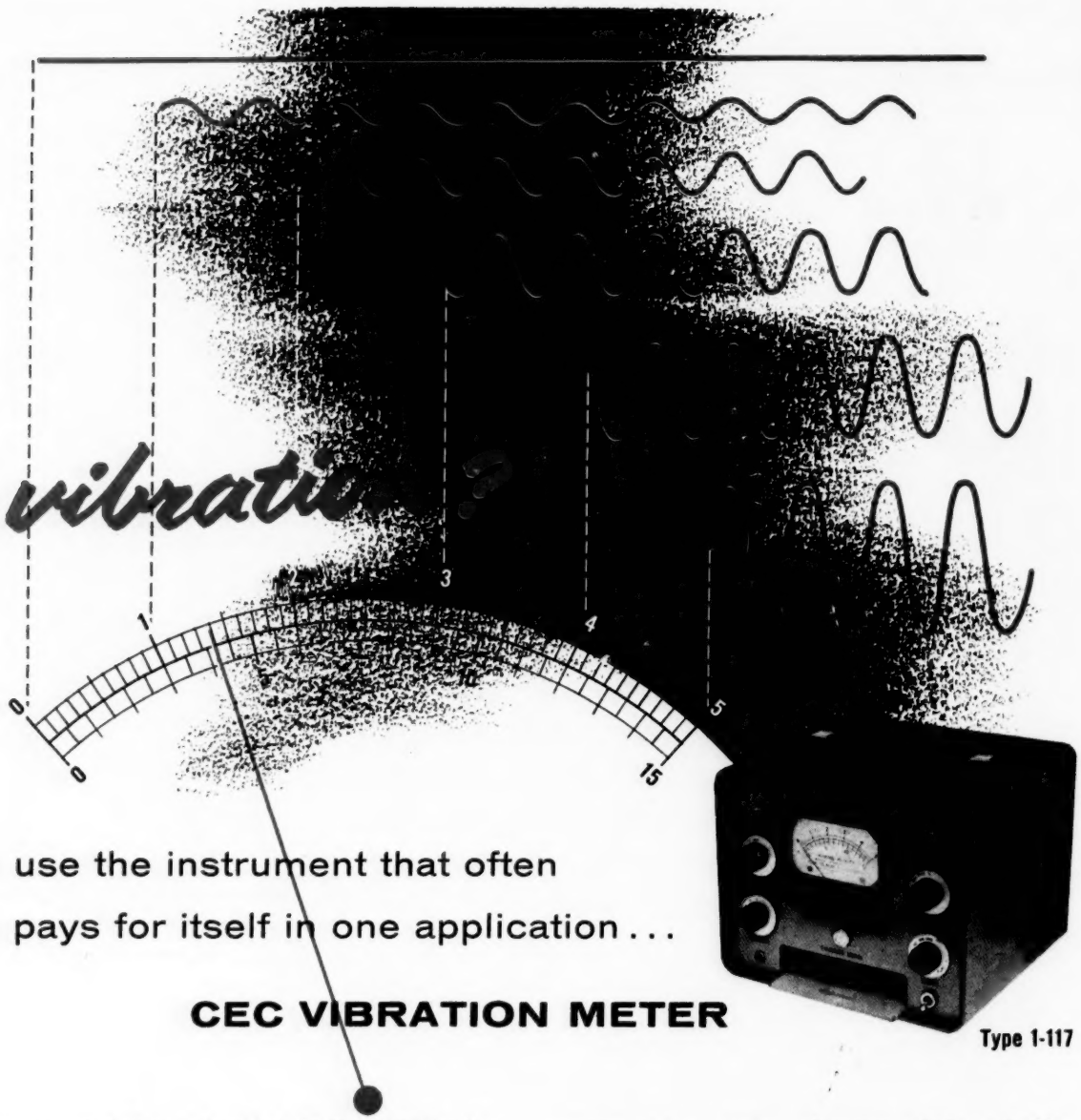
NEW DEPARTURE BALL BEARINGS

NEW DEPARTURE—World's Foremost Producer of Fine Ball Bearings

BALL BEARINGS MAKE GOOD PRODUCTS BETTER

NEW DEPARTURE • DIVISION OF GENERAL MOTORS • BRISTOL, CONN.

For more information circle **35** on inquiry card.



use the instrument that often

pays for itself in one application . . .

CEC VIBRATION METER

Type 1-117

When control of vibration is critical, CEC's 1-117 Vibration Meter is one of the best investments your company can make. Extremely versatile, accurate and rugged, the portable 1-117 is recommended for any vibration analysis where 115 volt, 50/60/400-cycle a-c is available.

Case histories prove this quality instrument quickly paid for itself many times over in laboratories and jet-engine production and overhaul facilities . . . more than doubled machine tool life by pinpointing vibration amplitudes of less than 0.0001".

PROVIDES DIRECT READINGS of average velocity and either linear or torsional peak-to-peak displacement on a large, easy-to-read meter. Output may also be connected to an oscilloscope or oscillograph for more detailed wave-form study.

FEATURES 4 INPUT CHANNELS with individually adjustable sensitivity . . . interchangeable high-pass filters for low-frequency cut-off . . . highly stable amplifier. The 1-117 is also adaptable to rack mounting. The only external accessories needed are suitably matched, self-generating pickups.

For complete specifications, please write for Bulletin CEC 1538B-X15, or contact your nearby CEC field office.

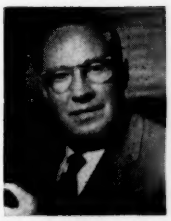
Consolidated Electrodynamics

CEC *300 North Sierra Madre Villa, Pasadena, California*

NATIONWIDE COMPANY-OWNED SALES & SERVICE OFFICES

For more information circle **36** on inquiry card.

People IN THE NEWS



Charles H. Fetter
American Time

W. B. Denniston
Panellit

N. W. Hartz
Mine Safety

CONSOLIDATED ELECTRODYNAMICS has appointed *William M. Hawkins, Jr.* as sales manager of the Electronic Industries Div.

William M. Hawkins, Jr.
CEC

William R. Kennedy
H-D

HAMMEL-DAHL announces appointment of *William R. Kennedy* as assistant sales manager.

BAUSCH & LOMB has promoted *Herbert J. Mossien* to manager of the Scientific Instrument Sales Div.

BECKMAN INSTRUMENTS reports appointment of *Anthony M. Johnson* to product line sales manager, Systems Div.

VICTOREEN has named *Duane M. Mayhew* vice president of sales and a director of the company.

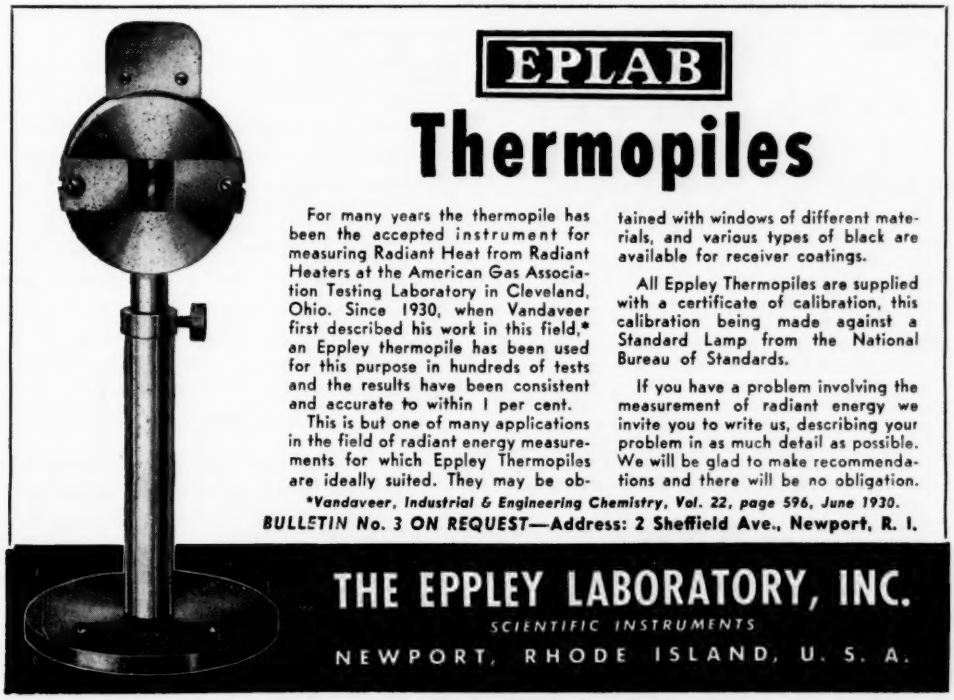
TAYLOR INSTRUMENT COS. have appointed *Nathaniel B. Nichols* chief engineer.

BAILEY METER CO. has appointed *Chas. E. Bergman* assistant advertising manager.

AMERICAN TIME PRODUCTS' founder *Charles H. Fetter* has received a plaque from the "Free Enterprise Awards Association", honoring him for outstanding success "possible under our Free Enterprise System."

PANELLIT has named *William B. Denniston* sales manager and *John R. Warren* general superintendent of the Contracting Div. of Panellit Service Corp., its subsidiary.

MINE SAFETY APPLIANCES has named *H. B. Stafford* as operations manager and *N. W. Hartz* as sales manager of its newly established Technical Products Div.


EPLAB
Thermopiles
For many years the thermopile has been the accepted instrument for measuring Radiant Heat from Radiant Heaters at the American Gas Association Testing Laboratory in Cleveland, Ohio. Since 1930, when Vandaveer first described his work in this field,* an Eppley thermopile has been used for this purpose in hundreds of tests and the results have been consistent and accurate to within 1 per cent.
This is but one of many applications in the field of radiant energy measurements for which Eppley Thermopiles are ideally suited. They may be obtained with windows of different materials, and various types of black are available for receiver coatings.
All Eppley Thermopiles are supplied with a certificate of calibration, this calibration being made against a Standard Lamp from the National Bureau of Standards.
If you have a problem involving the measurement of radiant energy we invite you to write us, describing your problem in as much detail as possible. We will be glad to make recommendations and there will be no obligation.
*Vandaveer, Industrial & Engineering Chemistry, Vol. 22, page 596, June 1930.
BULLETIN No. 3 ON REQUEST—Address: 2 Sheffield Ave., Newport, R. I.
THE EPPLEY LABORATORY, INC.
SCIENTIFIC INSTRUMENTS
NEWPORT, RHODE ISLAND, U. S. A.
For more information circle 37 on inquiry card.

MEASURE MICROVOLTS *without pre-amplification!*

403

$580.

FEATURING

AMPLIFIERS: Direct coupled amplifiers with single-ended or balanced input.

EXTREME SENSITIVITY: 5 millivolt to 500 volts full scale, continuously variable. Additional sensitivity for short term measurements, with resolution down to 20 microvolts.

FREQUENCY RANGE: DC to 300 KC.

Y AMPLIFIER CALIBRATION: 5%.

SWEEPS: 19 calibrated linear sweeps, 0.5 sec/cm to 0.5 usec/cm. Calibrating accuracy, 5%.

EXPANDED SWEEP: Any 10 cm portion of 50 cm sweep may be expanded 4 times and positioned on screen.

Price **$580.00**
Slightly higher in 50 cycle areas

TYPE 403R Rack mounted version, electrically identical to Type 403 $595.00

Complete Details On Request...

The Type 403 is the most sensitive oscilloscope commercially available. It permits direct measurements from low output transducers such as strain gages, pressure pickups, accelerometers, and others that normally require preamplifiers.

When used as a direct reading voltmeter, the Type 403 offers stability of better than 1 millivolt per hour for all ranges from 500 volts all the way down to 5 millivolts full scale. A super sensitive range is available of 1 millivolt full scale (100 microvolts per scale division) for short term measurements.

This outstanding performance is wrapped in the nicest package in the industry. The 403 features "human engineering" resulting in easier operation, complete accessibility and unsurpassed reliability backed by a 5-year guarantee.

ANOTHER OF THE 400 SERIES

DU MONT

TECHNICAL SALES DEPARTMENT,
Allen B. Du Mont Laboratories, Inc., Clifton, N. J.

For more information circle **38** on inquiry card.

New Plants and Mergers

SUPERIOR TUBE CO. has authorized construction of a 2-million dollar new office building and factory addition to its main plant.

UNIVERSAL TRANSISTOR PRODUCTS CORP. has acquired a new air-conditioned 12,500-sq-ft plant in Westbury, L. I., N. Y.

PERKIN-ELMER CORP. recently started a new addition to its main plant, which will increase facilities by 80%.

J. BISHOP & CO. PLATINUM WORKS has expansion program, which calls for relocation of several plants and offices and construction of a new two-story building.

AMPEX CORP. has acquired 25% interest in Orradia Industries, Inc., a tape-making firm of Opelika, Alabama.

THE BRISTOL CO has recently moved its Pittsburgh district office to a new building which houses the sales

and service staffs. It has also opened new branch factories and repair laboratories in Houston and Los Angeles.

GENERAL PRECISION LAB has opened a new 23,200-sq-ft test building in Pleasantville, N. Y.

KAY LAB has sold its assets to Cohu Electronics, Inc. which will be the company's new name.

FISCHER & PORTER and Paterson Engineering Co., Ltd., of London, England, announce formation of a new British company, Chlorination Equipment, Ltd.—The company also announces a new agreement with the Hokushin Electric Works of Tokyo, by which the Japanese firm will begin manufacture of all products now produced by Fischer & Porter.

LORAL ELECTRONICS has completed its $1½ million 100,000-sq-ft plant in the Bronx.

AUTOMATIC ELECTRIC CO. is moving its facilities from Chicago to a new plant in Northlake, Ill.

IMPERIAL Hi-Duty®

Tube fittings

36 to 77% savings in installation time!

Just push tube into fitting without removing nut and tighten...that's all

Tests reveal Hi-Duty fittings make tube connections in *36%* less time than regular compression fittings . . . *77%* less time than flare fittings. Unit has one-piece nut and sleeve. The sleeve shears off in assembly. You get stronger joints because sleeve is always in perfect alignment.

Takes up to 5 times more vibration than ordinary compression or flared fittings. Fittings remain leakproof, even under severe service. Exclusive design minimizes deformation of tubing.

Furnished in brass or aluminum, for ⅛ to 1" O.D. tubing.

Ask for Bulletin No. 3002

IMPERIAL Hi-Duty® Shut-off Valves

Perfect fluid control! Best protection against leakage. Positive shut-off. 2, 3 and 4-way types. Low and medium pressures.

THE IMPERIAL BRASS MFG. CO. 1204 W. Harrison St., Chicago 7, Ill.

In Canada: 334 Lauder Ave., Toronto, Ontario

IMPERIAL Industry's Most Complete Line of Tube Fittings and Tubing Tools

For more information circle **39** on inquiry card.

280 SERIES METERING VALVES for

precise control

20 TURNS moves the stem only 3/8"

For precision flow control use this brass bar stock metering valve, equipped with an O-ring stem seal. The extra long, sharp, needle point stem (8° included angle) and fine spindle threads insure accurate control for pneumatic or hydraulic service, or precision laboratory work. In ⅛" and ¼" pipe sizes. Your choice of 1/16" or ⅛" orifices. Available for Panel Mounting, too.

For complete information send for Bulletin No. BSV 256.

HOKE

HOKE INCORPORATED

Fluid Control Specialists

231 S. DEAN STREET, ENGLEWOOD, N. J.

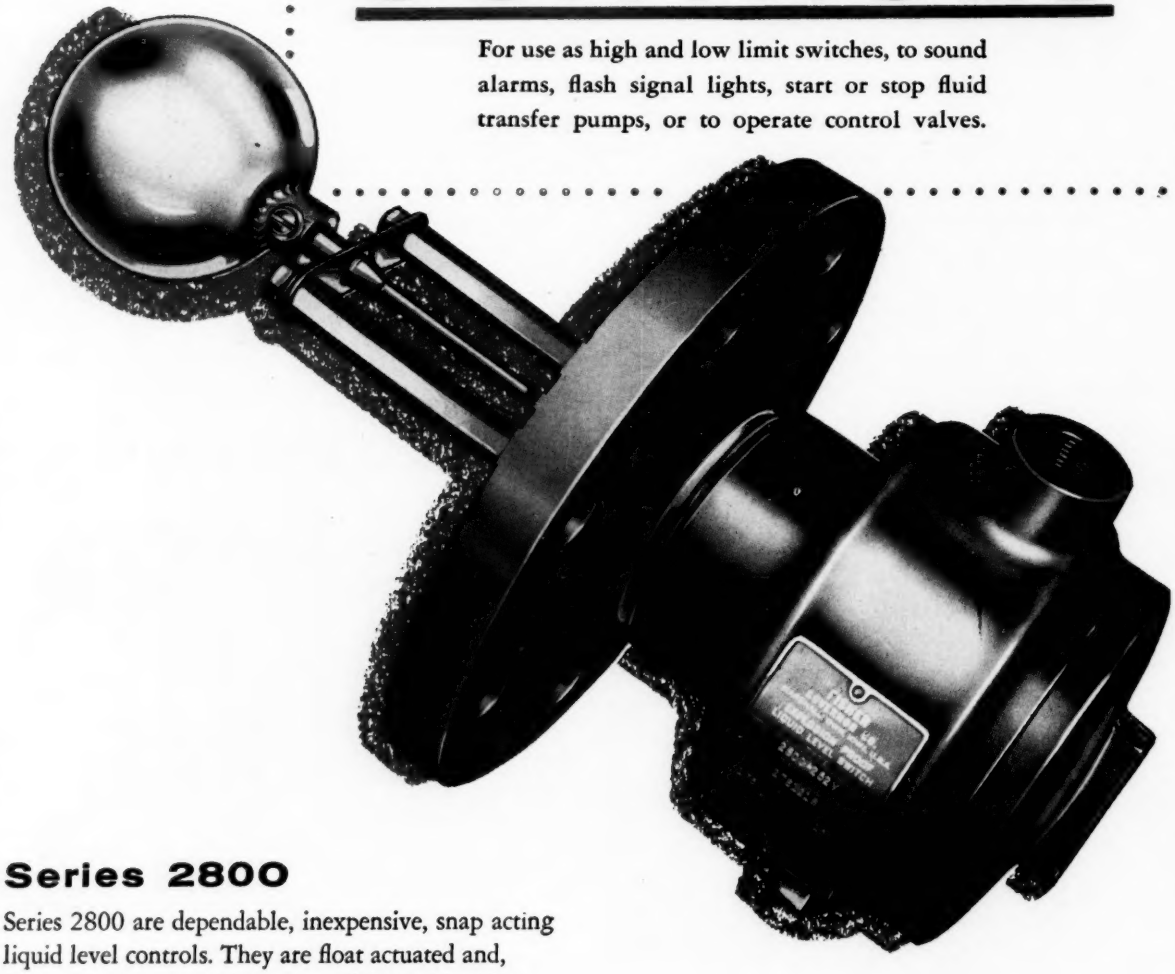
For more information circle **40** on inquiry card.

FISHER

Series 2800

Liquid Level CONTROLS

For use as high and low limit switches, to sound alarms, flash signal lights, start or stop fluid transfer pumps, or to operate control valves.



Series 2800

Series 2800 are dependable, inexpensive, snap acting liquid level controls. They are float actuated and, for maximum versatility, are available with either electric (explosion-proof) or pneumatic switch action. Either pilot type is interchangeable on the same float housing assembly. Stab-in type of tank mounting provides easy installation. Available with 4″ iron or steel flanged tank connection. Write for Bulletin F-2800 for complete information.

FISHER GOVERNOR COMPANY
Marshalltown, Iowa • Woodstock, Ontario

For more information circle **41** on inquiry card.

Biographies of significance

SIGNIFICANCE

UNION CARBIDE AND CARBON Chemicals Corporation enjoyed reknown before it was granted the impressive responsibility of operating the Government's Oak Ridge facility, and since has become synonymous with pioneering production in the amazing new nuclear industry. N. L. (Tiny) Isenhour, now Superintendent of the General Engineering Departments at Oak Ridge, has enjoyed one of the most unique careers in modern instrumentation. His tenure with Carbide and Carbon encompasses the initial planning, construction and operation of instrumentation of this important plant, and he is one of the best known "instrumenticians" in the country. We are proud to acknowledge Tiny Isenhour's position in our field, and his important contribution to the development of instrumentation in general, and at Oak Ridge in particular.

N. L. ISENHOUR

NOEL LEE ISENHOUR, affectionately known as "Tiny" because of his 6′ 3″ height, started his career in instrumentation in September, 1936, as an instrument mechanic with Riverside and Dan River Cotton Mills at Danville, Virginia.

He had graduated from George Washington High School in Danville, Virginia, where he played basketball and football. With many scholarship offers, he accepted the one from Duke University. Entering Duke in the fall of 1932, he had to leave owing to financial reasons in May 1933, during the big depression. Although his formal education ended at that time, his instrument education began—and has never ended, as his career shows.

His first interest in instrumentation developed from an International Correspondence course in air conditioning, studied during the early part of 1936. Also, his responsibilities at Riverside (maintenance of the American Moistening Company and Parks Cramer Humidifier control systems, size mixing and cooking, and various temperature control systems) led him directly into instrument work. As he became more familiar with the instruments, it became apparent to him that here was a type of work that was non-routine and interesting, that offered a challenge to his ability to think and reason out the solution to various problems. At this time he made the decision to enter the instrumentation field, and soon fell heir to the basic instrument maintenance work at his plant.

In January, 1939 he moved to work in the Maintenance Department of the American Viscose Corporation in Front Royal, Virginia. As Temperature Control Department Foreman, his responsibility included operation of all heat-exchange and air-conditioning equipment, as well as maintenance and repair of all instrumentation throughout the plant.

As the plant was still under construction, and as there were no trained personnel available, one of his first responsibilities was to organize the department and train personnel. After this was accomplished, his responsibilities were to check and put into operation all instrumentation installed by the contractors. This was accomplished and the plant was in continuous successful operation at the time he left Viscose in September, 1943, to accept a position with Union Carbide and Carbon Chemicals Corporation.

Immediately upon joining Carbide and Carbon in New York City he was assigned to the Oak Ridge Gaseous Diffusion Plan project for Oak Ridge, Tennessee.

During November and December he was at the Kellex Laboratories, located at the M. W. Kellogg Plant site in Jersey City, working on instrumentation problems for the laboratories. From January to April, 1944, he was at the SAM Laboratories of Columbia University, becoming familiar with instrumentation to be installed in the Oak Ridge Gaseous Diffusion plant and also supervising installation of instrumentation on a pilot plant used for checking out some pumping equipment being considered for the plant.

It wasn't until April 17, 1944, that he was transferred to Oak Ridge. First responsibility was to the Kellex organization in helping install the first unit in the Oak Ridge Gaseous Diffusion Plant. Being the only person in the area familiar with the instrumentation, his responsibility required making sketches and actually supervising the first installation.

It became apparent there was a dire need for instrumentation operating instructions for use by the operating personnel. Tiny spent about two and one-half months preparing these instructions, which instructed operators in making the instrument adjustments required to assure proper operation of the plant.

In November, 1944, he organized a construction group which was responsible for following the field construction and making final acceptance of the instrumentation. In May, 1945, he was given the responsibility of supervising the newly organized Instrument Engineering Department which consisted of forty engineers and forty-five construction mechanics. During the period from May 1945 until May 1947, the department devoted its time in working out the bugs in the instrumentation required to get the plant into full operation.

On June 1, 1947, the Instrument Engineering Department became a part of the Plant Engineering Division and the Instrument Maintenance Department was transferred to the Maintenance Division. During the period 1947 until 1949, the efforts of the department were spent in making general plant changes, additions, modifications, and working out improvements to increase plant efficiency.

Then, in 1949, there began an expansion program, resulting in additional processing facilities at Oak Ridge and two additional new plants at Paducah, Kentucky and Waverly,

Between Concept and Configuration

...Save Time and Money with

PHILBRICK PLUG-IN DC

AMPLIFIERS

AVAILABLE FROM STOCK

For a wide variety of instrumentation and control problems, you can facilitate rapid set-up with either one or both of these octal-based, plug-in Philbrick Amplifiers. Operational Amplifier, Model K2-W, features balanced differential inputs for minimum drift and maximum utility. In conventional applications, overall amplifier characteristics are affected solely by the feed-back networks, since the two inputs can be maintained at nearly equal potential with appropriate feed-back circuitry.

For more critical applications where long term drift must be reduced to sub-millivolt levels, Stabilizing Amplifier, Model K2-P, is paired with Model K2-W. *Write for free 28 page Plug-In Amplifier Applications Manual-12.*

MODEL K2-W	MODEL K2-P
GAIN: 15,000 dc, Open Loop	GAIN: 1,000 dc
POWER REQUIREMENTS: 4.5ma @ ±300 vdc, 0.6 amps. @ 6.3v	POWER REQUIREMENTS: 2.4 ma @ +300 vdc, 0.45 amps. @ 6.3 vac, 60 cps
OUTPUT RANGE: +50v. to −50v. at 1 ma	INPUT IMPEDANCE: 1 Megohm
RESPONSE: 2 Microseconds rise time, 100 Kc with unity feed-back	STABILITY: Below 100 Microvolts
PRICE: $24.00 Postpaid	PRICE: $60.00 Postpaid

GEORGE A. GAP/R

PHILBRICK

RESEARCHES, INC.

230 Congress Street, Boston 10, Massachusetts HUbbard 2-3225

For more information circle **42** on inquiry card.

BIOGRAPHIES—CONT.

Ohio. From 1949 to the completion of construction in 1955, the Instrument Engineering Department had full responsibility for the design and procurement of all instrumentation for these plants. The total instrumentation installed has a present dollar value in the order of $40 million. Of this amount, about $30 million were new purchases and the other $10 million represented instruments and equipment salvaged out of the old Oak Ridge Gaseous Diffusion Plant. Tiny comments, "We have in our organization a number of instrument engineers who have been with us from nine to ten years and in my opinion could be considered among the best in the country."

In February, 1955, he was transferred from the Instrument Engineering Department to the Project Engineering Department.

On October 9, 1956, Tiny was given a new assignment, as the superintendent of the General Engineering Departments. His duties in this position include the administration and supervision of the Civil, Mechanical, Electrical and Metallurgical Engineering Departments with a total of more than sixty personnel. These departments are responsible for the design, specifications, etc. for all of the changes and alterations required to keep the plant in operation, as well as the improvements made to increase the over-all plant efficiency.

Tiny is an active society man, and was honored by being elected Vice President of ISA, 1950-1952. He is a member also of the American Society of Mechanical Engineers, Society for Advancement of Management, the ASA Subcommittee—C39-3, ASA Committee-C85 (Instrument Terminology), and ASA Subcommittee-C85-1 (Types and Components).

Tiny says "I have been reading *Instruments and Automation* for 14 years—since 1943. It has been a continued source of information to me on new products, developments, and the know-how for solving a number of my problems. It is highly regarded by the men in the Instrument Engineering Department of this facility; from 80 to 90% of them subscribe to or read it."

Tiny met his wife (red-headed Louise Apperson from Culpepper, Virginia) in Front Royal, Virginia in August 1939. They were married July 27, 1940 and now have two red-headed boys—Bill (5′ 10″, weight 185, age 14) and Jack (5′ 0″, weight 114, age 12), with whom Tiny enjoys his outside interests—gardening and fishing.

ARNOUX ... announces

ELECTRONIC COMMUTATION

... FOR *Airborne* TELEMETRY

Model ETC-30-10-P.A.M.-1

30 Channels — 10 Samples / Sec.

- Directly replaces mechanical commutators in 0-3 Volt and 0-5 Volt airborne telemeter applications.
- Available in all standard sampling rates required for P.A.M. and P.D.M. commutated systems.
- Meets all I.R.I.G. requirements, exceeds MIL E-5272A specification.
- Errors due to drift, cross-talk and non-linearity less than 0.50 percent under MIL E-5272A environment.
- Noise-free operation assured for thousands of hours without maintenance.
- Twenty-Seven (27) information channels, plus Master pulse.
- Unique limiting feature eliminates need for limiters elsewhere in system.
- Power Requirement: 150V DC at 12 ma.
- Size: 3" diameter x 5" long.
- Weight: Less than 2 pounds
- Extreme reliability is achieved through use of a simplified counter circuit in conjunction with an advanced-design silicon diode switching matrix.
- Design life expectancy is at least 5000 hours without maintenance of any kind.

WRITE FOR ARNOUX BULLETIN 700

ARNOUX CORPORATION

Designers and Manufacturers of Precision Instrumentation

11924 WEST WASHINGTON BLVD. • LOS ANGELES 66, CALIFORNIA

PHONE TExas 0537 1 • EXmont 82707 • TWX S MON 7498

For more information circle **43** on inquiry card.

THERMISTOR DEVICES GIVE 1 TO 100 POINT TEMPERATURE CONTROL

Fenwal Units' Accuracy is .25% of Scale

ASHLAND, MASS. — Fenwal engineers here have designed a new Controller using a thermistor and a simple electronic circuit, and the result is a temperature-control system versatile and accurate to within .25% of scale.

The thermistor principle is this: the electrical resistance of the sensing element decreases as its temperature rises. The resistance changes for very small temperature changes are large, making extremely accurate temperature measurement possible.

In the Fenwal system, the thermistor, with its amazing sensitivity and fast responses, feeds an electronic bridge circuit that uses standard tubes. The small thermistor probe, available in several styles, is mounted at the point you wish controlled.

You can mount the compact Unit Controller up to 200 feet away from the control point without losing sensitivity. You can connect it with ordinary lamp cord.

Tailor-Made Designs

But possibly the biggest news in the design is the way the Unit Controllers can be assembled with a common power supply, like building blocks, to provide you with a central system serving up to 100 control points.

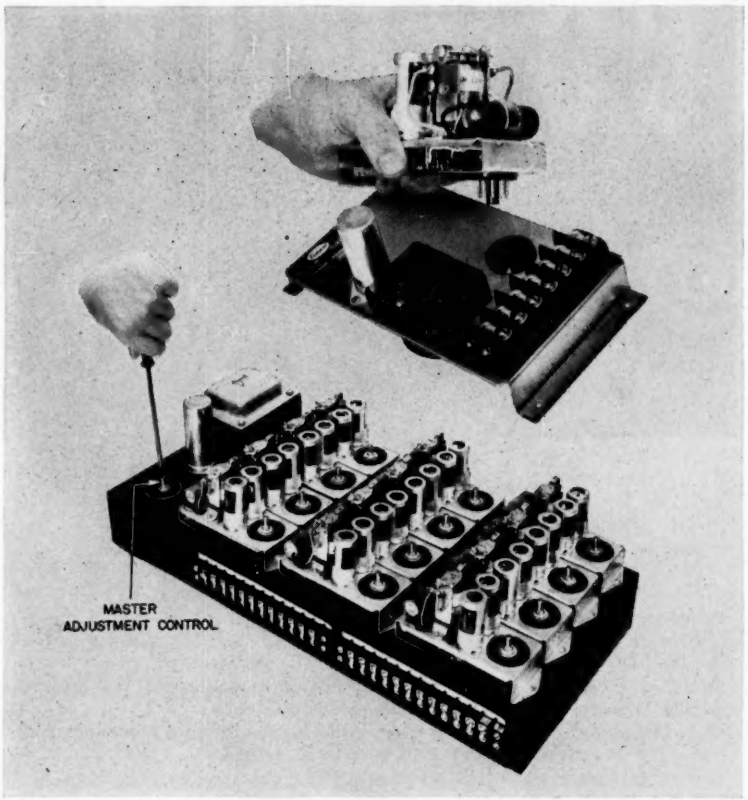
The units are, of course, ideal for use singly as well — each unit serving a single control point, each unit with its own power supply.

The many possible combinations of units are known collectively as the Fenwal Series 53000. There are four standard temperature ranges for you to choose from: −100°F to 50°F; 0°F to 150°F; 100°F to 300°F; and 200°F to 600°F. Special ranges can, of course, be supplied in most cases.

Each Controller includes a potentiometer for temperature adjustment, which you can locate remotely, if you wish. For multiple units, you can have a single master control. This control will let you adjust a complete system, while permitting compensating adjustment for each individual Controller, too.

These Thermistor Controllers are already serving hundreds of companies in many industries. Why not yours? You'll be surprised how inexpensive good control can be.

Designers and process engineers — you will want to have details on this new advance in precision temperature control at your fingertips. Write for information on the Series 53000 Unit Thermistor Controllers to **Fenwal Incorporated, 367 Pleasant Street, Ashland, Mass.**



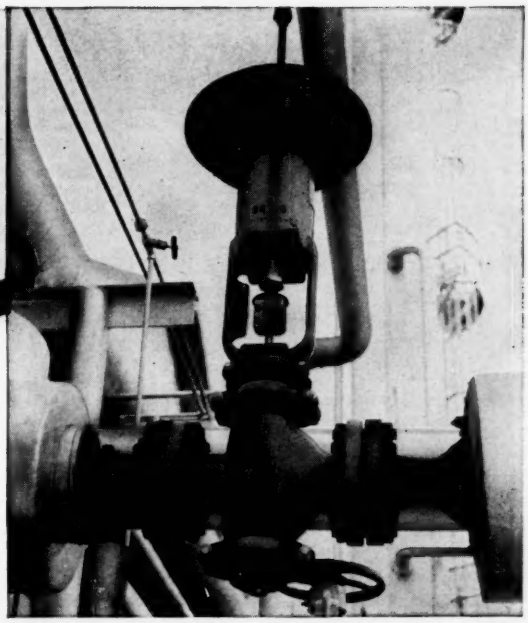
FENWAL'S SERIES 53000 UNIT THERMISTOR CONTROLLER — Serves a single temperature control point, but can be combined easily with others, like building blocks, to make up a central system serving up to 100 control points with a single master control if desired. You should know about this. Write Fenwal for details.

Fenwal

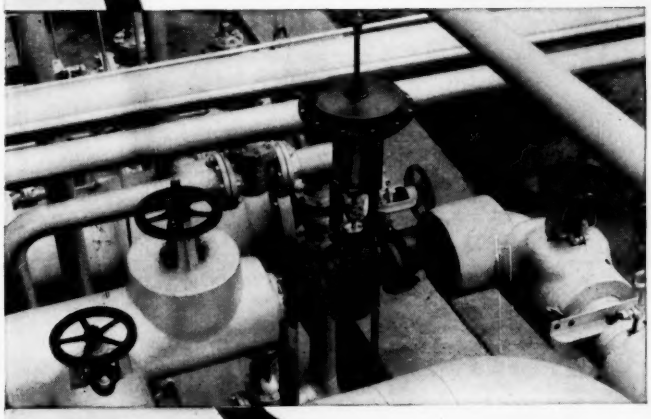
CONTROLS TEMPERATURE . . . *PRECISELY*

For more information circle **44** on inquiry card.

ON STREAM...



BS&B's NEW *Super* 70 *series*



Entirely New Actuator Gives Accurate Linear Response!

- ✓ Choice of direct or reverse acting types in four sizes.
- ✓ Buna-N moulded diaphragm, reinforced with Nylon, gives uniform effective area through full valve travel.
- ✓ Cadmium plated pressed steel diaphragm cases give maximum strength and corrosion resistance with minimum weight.
- ✓ Bolted clamp ring, joining body and actuator, permits yoke to be oriented to any convenient position.

New Valve Body Gives Greater Stability Than Ever!

- ✓ Choice of single port, double port or split body.
- ✓ Streamlined contours provide more stable flow at all inner valve positions.
- ✓ Precision inner valves give more exacting flow characteristics.
- ✓ Patented float ring provides positive self-actuating seal.

EFFICIENCY · OVER 60 YEARS · BS&B · RELIABILITY · ANOTHER EXAMPLE OF PRODUCT LEADERSHIP

For more information on the all-new BS&B Super 70 Series Diaphragm Control Valves, ask your BS&B Sales Engineer—or write for Catalog 70-11.

BLACK, SIVALLS & BRYSON, INC.

Controls Division, Dept. 4-V7

7500 East 12th Street **Kansas City 26, Missouri**

For more information circle **45** on inquiry card.

EQUIPMENT MANUFACTURERS:

PROCESS CONTROLLERS

AUTOMATIC PRODUCTION MACHINERY

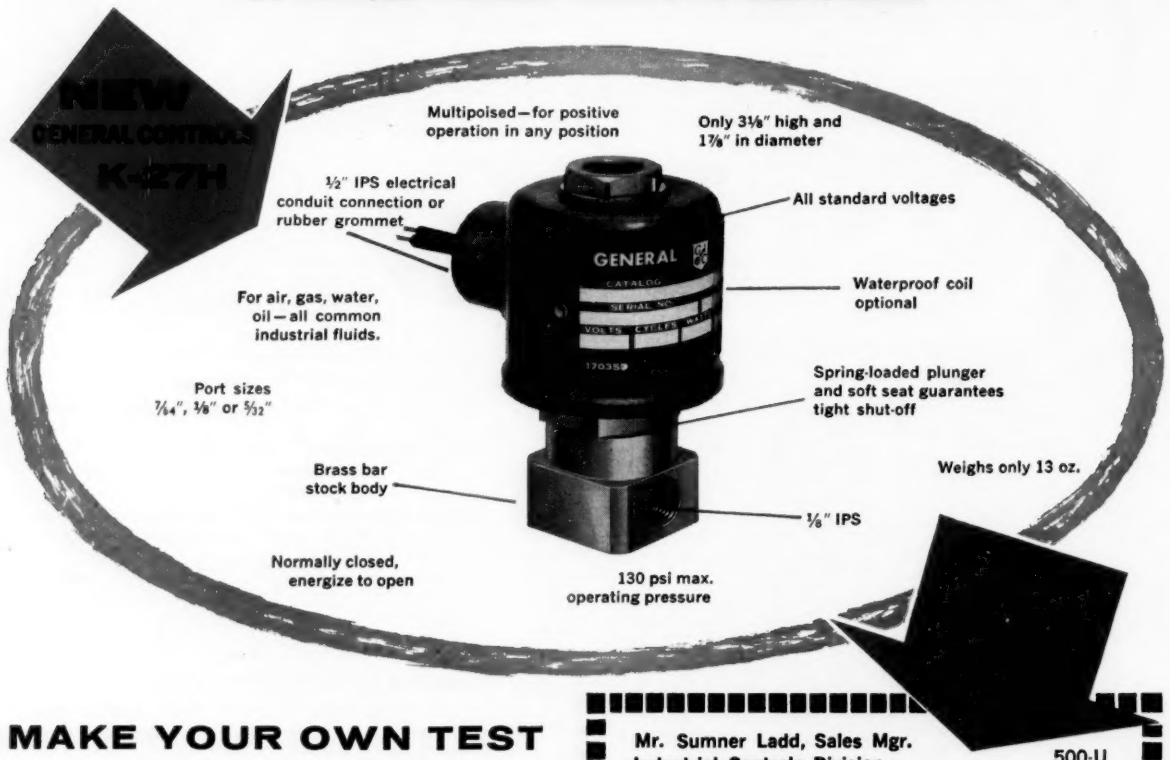
VENDING MACHINES

TEST BENCHES

send for FREE sample

SMALL SIZE...LOW COST...MIDGET SOLENOID VALVE

BY THE WORLD'S LARGEST MAKER OF AUTOMATIC VALVES



MAKE YOUR OWN TEST

If you make equipment that incorporates small solenoid valves, you'll want to find out first-hand about this smaller and lower cost valve that will save space, reduce costs and (most important) deliver the goods in dependable performance.

We're so convinced this new K-27H Midget Solenoid Valve will give you all three, we'd like you to try it on your equipment for size—savings and performance. Send in the attached coupon.

GENERAL CONTROLS

America's Finest Automatic Controls for Home, Industry, and the Military

Glendale, California · Skokie, Illinois

Five Plants—40 factory branch offices serving the United States and Canada

Mr. Sumner Ladd, Sales Mgr.
Industrial Controls Division
General Controls Co.
801 Allen Avenue, Glendale 1, Calif.

500-U

Please send me a **free** sample of your new K-27H Midget Solenoid Valve for test and evaluation on equipment we manufacture for sale.

NAME_____

POSITION_____

COMPANY_____

ADDRESS_____

CITY_____ STATE_____

TYPE OF EQUIPMENT MANUFACTURED_____

_____

For more information circle **46** on inquiry card.

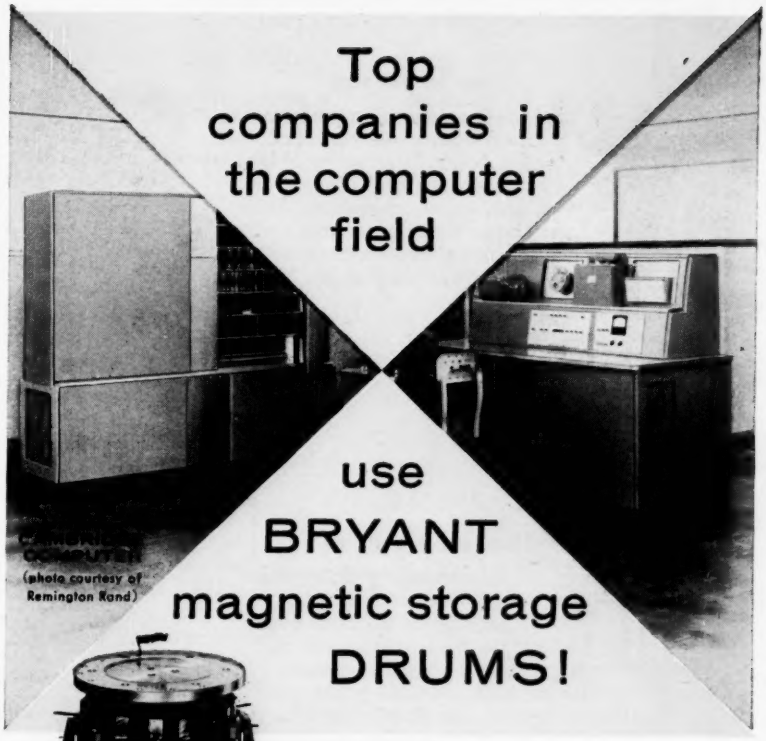
Books

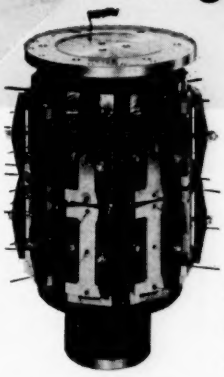
Guide for Machinery Buyers published for VDMA (Association of German Machinery, Frankfurt a/M) by Heppenstedt Wirtschaftsverlag G.m.b.H., Darmstadt (9⅞" x 4"). Contains (AI) Alphabetical Index of Products from "Abaca" to "Zyclos"; (AII) Register of Suppliers in 37 groups from Machine Tools to Products of Industries Related to Mechanical Engineering (which constitutes the bulk of the pages in the book); (B) Alphabetical Directory of Manufacturers; and (C) Special Business Service; as well as advertisements and advertisers' Index.

Messen und Regeln in der Chemischen Technik, edited by J. Hengstenberg, B. Sturm, and O. Winkler. Springer-Verlag, Berlin, Germany; 1261 p., 1331 illustrations; DM 146.00 (approx. $39.00), 10 in. Encyclopedia of measurement and control in chemical plants in nine elaborate chapters, written by 31 experts in their fields. Chapters cover: Temperature; Weight, Flow, Level; Controllers and Control Theory. Includes American products and methods in short chapter.

Fundamentals of Chromatography by Harold Gomes Cassidy. (Vol. X of Technique of Organic Chemistry; edited by Arnold Weissberger.) 1957. Interscience Publishers, Inc., 250 Fifth Ave., New York 1, N.Y. 396 p. $9.75. Author approaches chromatography on the level of principle, with illustrations showing applications, leading reader to a deeper understanding of fundamentals and the how and why of chromatography.

Transistors Handbook, by William D. Bevitt. 1956. Prentice-Hall, Inc., Englewood Cliffs, N. J. 410 p. Handbook is concerned with practical aspects of transistors, minimizing math; presents characteristics, measurements, circuit properties and behavior of the different types of transistors. Book includes diagrams of tested circuits, with typical values of circuit elements, and a subject index for easy reference to the material.





Bryant Magnetic Drums are used extensively by Remington Rand—Univac and other leading manufacturers of electronic computers, because of their accurate, dependable performance. These drums are used not only in digital computers, inventory control systems and tape-to-card converters, but also as delay lines, synchronizers and frequency generators.

FEATURES

- Designed to purchasers' requirements
- Guaranteed accuracy of drum runout .00010" T. I. R. or less
- Air bearings or super-precision ball bearings
- Belt drive or integral motor drive, speeds to 100,000 RPM or more
- Capacities to 5,000,000 or more binary digits
- Vertical or horizontal housing
- Head mounting surfaces to suit
- High density magnetic oxide coating

BRYANT GAGE and SPINDLE DIVISION
P. O. Box 620-I, Springfield, Vermont, U. S. A.
DIVISION OF BRYANT CHUCKING GRINDER CO.

For more information circle **47** on inquiry card.

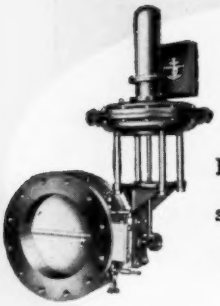
Needle Valves

Rugged, outstanding performers for proportional control of small flows. Interchangeable seat rings and plugs. For water, gas, steam, chemicals. Trim and body materials available for "difficult" fluids. Shown here with unique *reversible* Stabilflo Motor.

GET THE BEST

Saunders Type Valves

A complete line, particularly suited to handling of highly corrosive fluids, or fluids containing solids in suspension. Available with Stabilflo Motor as shown, or with Stabiload Cylinder and Power Positioner.

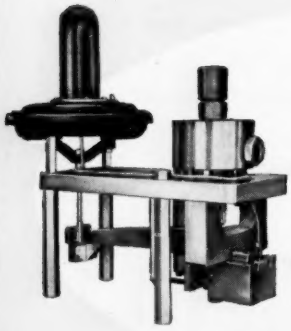


Butterfly Valves

Light and heavy duty types, with angle or swing-through seating, in spool or wafer body style, for low pressure air, gases in combustion control, steam, high pressure gases and liquids, etc. Available with Stabilflo Motor (shown) or cylinder operator.

Gate Valves

Guillotine-type slide valves, specially designed to handle pulp fibre, slurries, and similar fluids. Available with Stabiload Cylinder and Power Positioner as illustrated, for throttling service, or with 4-way pilot valve for on-off service.



Super-Pressure Valves

For throttling or let-down service up to 30,000 psi. Features an exclusive high-pressure bellows seal. Port sizes and connections to meet high pressure process specifications.

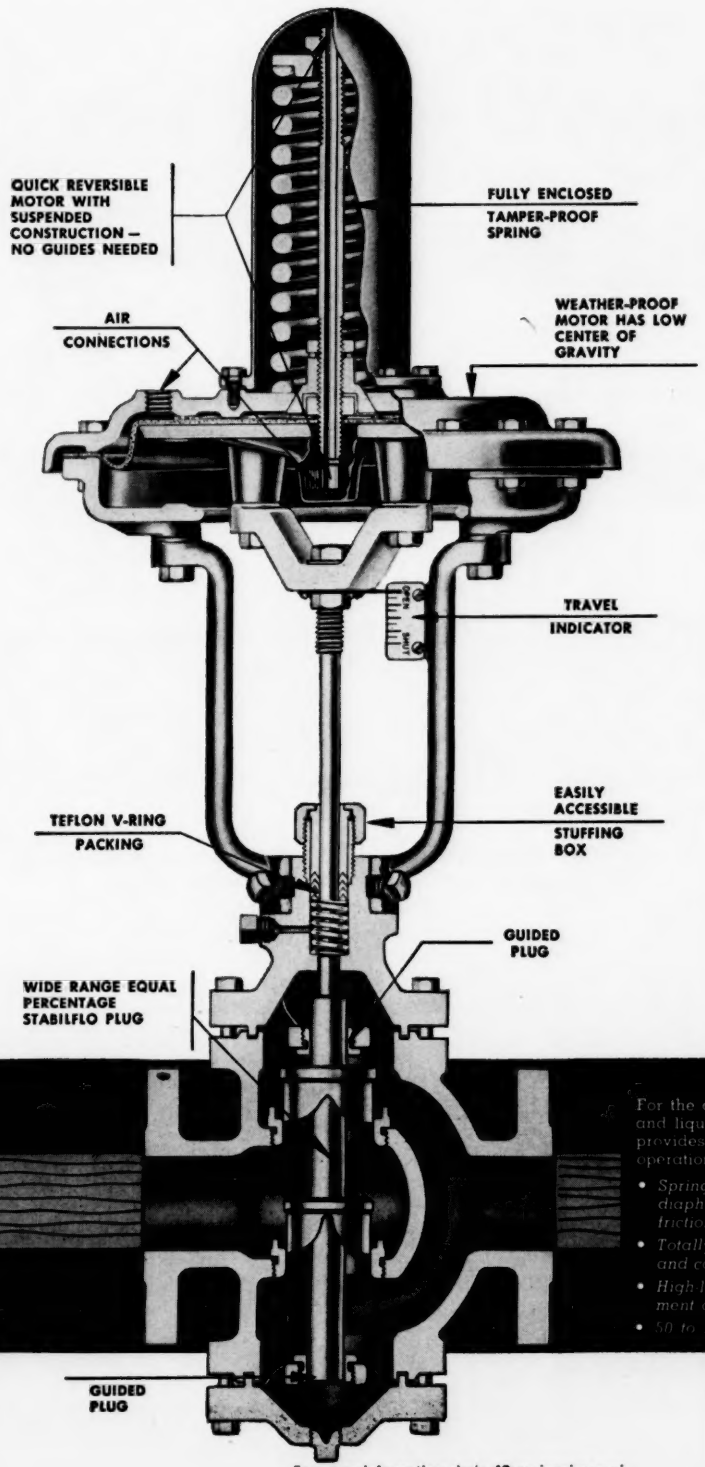
FOXBORO CONTROL VALVES

Reg. U.S. Pat. Off.

8 Strategic Branch Shops for Coast-to-Coast Service: **Pittsburgh, Pa. • Chicago (Skokie), Ill. • Dallas, Tex. • Houston, Tex. • San Francisco (San Leandro), Cal. • Los Angeles, Cal. • Montreal, Que. • Vancouver, B. C.**

SOLUTION TO YOUR CONTROL VALVE PROBLEMS

...with Foxboro Pneumatic Control Valves


QUICK REVERSIBLE MOTOR WITH SUSPENDED CONSTRUCTION — NO GUIDES NEEDED
FULLY ENCLOSED TAMPER-PROOF SPRING
AIR CONNECTIONS
WEATHER-PROOF MOTOR HAS LOW CENTER OF GRAVITY
TRAVEL INDICATOR
EASILY ACCESSIBLE STUFFING BOX
TEFLON V-RING PACKING
GUIDED PLUG
WIDE RANGE EQUAL PERCENTAGE STABILFLO PLUG
GUIDED PLUG

You can always be sure of getting the control valve best suited to flow conditions and control actions when you specify Foxboro. No other single source offers such a wide variety of control valves for specific applications. None other has Foxboro's experience in applying them — in every phase of industrial processing.

Your choice extends from valves for simple on-off control at one extreme, to specialized proportioning control at the other; for high vacuum work to operation at 30,000 psi; for temperatures from −350° to +1000°F. And there's a wide choice of plug designs — and of alloys and trim to handle even severely corrosive and erosive fluids.

You can save shipping cost and time, too, buying direct from Foxboro's strategically located branch shops. They're staffed by experts.

A few typical control valves from Foxboro's complete line are illustrated here. For full details, or specific information on *your* problem, call your nearby Foxboro Field Engineer or write **The Foxboro Company, 467 Neponset Ave., Foxboro, Mass.**

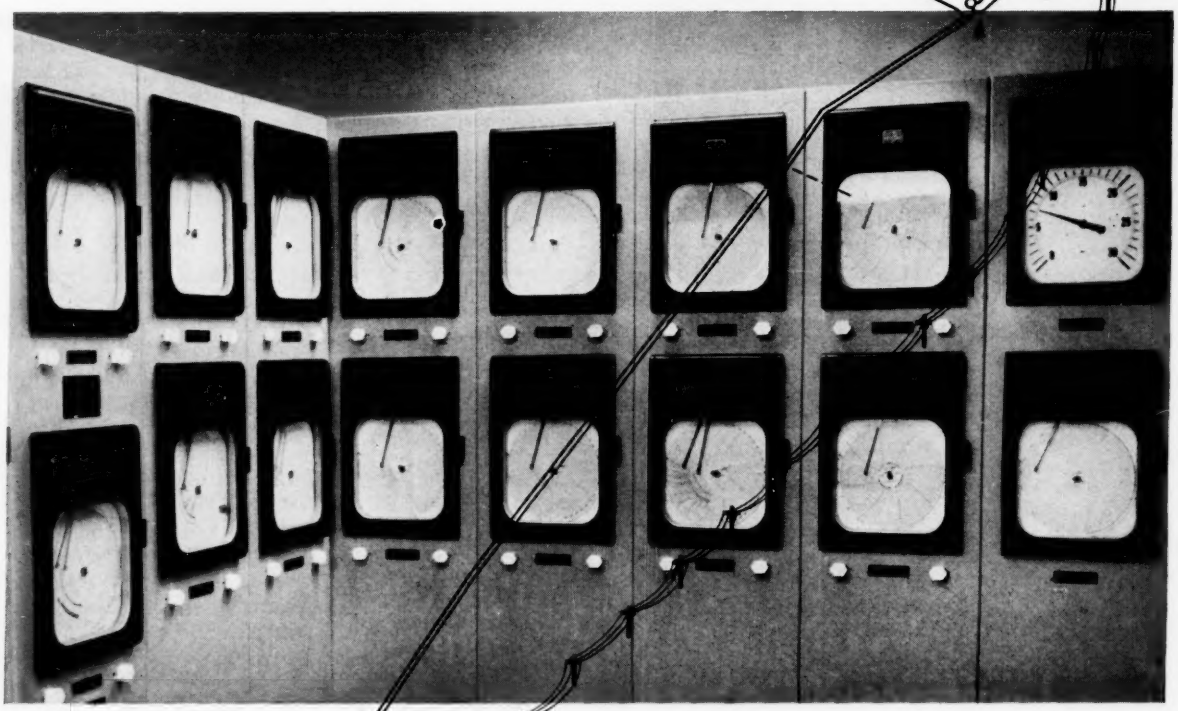
STABILFLO CONTROL VALVES

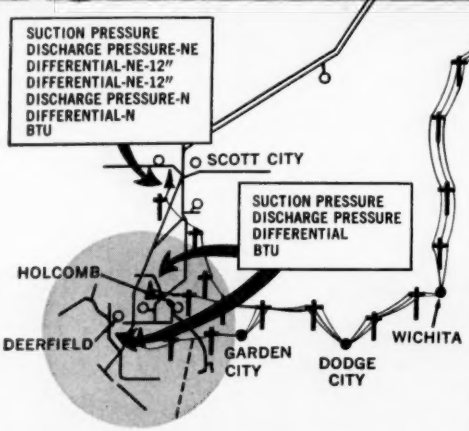
For the great majority of temperature, pressure, flow, and liquid level control applications, this basic valve provides unsurpassed sensitivity and troublefree operation. Unique design features:

- *Spring-above-diaphragm construction makes diaphragm motor self-aligning, virtually free from friction and hysteresis.*
- *Totally enclosed spring protects against tampering and corrosion.*
- *High-lift wide range V-port provides greater increment of lift for given change in air pressure.*
- *50 to 1 rangeability equal percentage characteristics.*

For more information circle **48** on inquiry card.

Bristol telemetering puts 24-hour guard on 700-mile pipeline





BRISTOL METAMETER* RECEIVERS (*photo, above*) at Kansas-Nebraska Natural Gas Company's Phillipsburg, Kansas, office give gas dispatcher complete data from field and compressor stations miles away—including suction, discharge, differential pressures and BTU values. Map shows telemetering system from southwest Kansas field to Phillipsburg. Pipelines serve Cozad and Grand Island, Nebraska (not shown).

Monitors BTU values as well as suction, discharge, differential pressures over far-flung natural gas system.

With a new Bristol multiplexed Metameter* telemetering system, Kansas-Nebraska Natural Gas Company, Inc. gets continuous supervision and remote-control from the dispatcher's office at Phillipsburg, Kansas, over pipelines from the southwest Kansas Hugoton Field to Cozad and Grand Island, Nebraska.

Compare this with the once-an-hour readings the dispatcher used to get with the old system! And these readings used to take 15 to 20 minutes to come in through the operator at Scott City, who radioed in readings from Lakin, Holcomb and Deerfield—as well as his own readings.

But the biggest advantage of all in the new system is the increased reliability and dependability Kansas-Nebraska is able to give customers.

Find out how advanced Bristol telemetering and centralized control systems can step up service and reduce costs on your pipeline. Write: The Bristol Company, 113 Bristol Rd., Waterbury 20, Conn.

*T. M. Reg. U.S. Pat. Off.

7.13

BRISTOL TRAIL-BLAZERS IN PROCESS AUTOMATION

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

For more information circle **49** on inquiry card.

Circle **50** on inquiry card. ⟶

"But I am constant as the northern star"

—Julius Caesar Act III Sc. 1

You know what to expect from CLARE Mercury-Wetted-Contact Relays—always. Their performance is CONSTANT.

Constant contact stability—No contact chatter—none at all.

Constant contact resistance—Repetitive measurements on individual relay contacts are constant to a few milliohms. Resistance of single contacts, including resistance of internal wiring between base terminals, ranges between 25 and 40 milliohms. Contact deterioriation cannot occur in this relay.

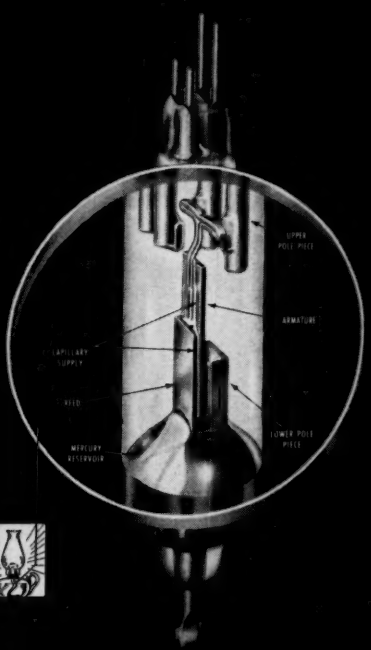
Constant operate time—Varies by only about 0.1 millisecond under constant drive conditions.

Constant pull-in current—Repetitive operating precision of given relay is within 1% of its minimum operating current. This precision is substantially independent of number of operations or ambient temperature.

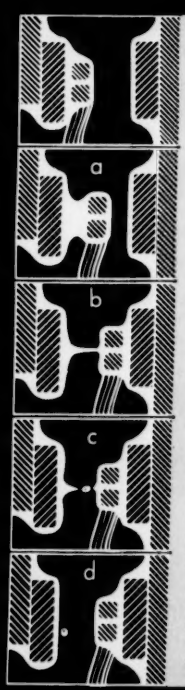
Constant adjustment—Requires no maintenance whatever. No possibility of change in adjustment. This remains true even after thousands of millions of operations.

If you have a job for which none but the best relay is good enough, it can cost you much more to settle for less than this CLARE RELAY. For complete information contact your nearest Clare representative or address C. P. Clare & Co., 3101 Pratt Blvd., Chicago 45, Illinois. In Canada: C. P. Clare & Co., 659 Bayview Avenue, Toronto 17. Cable address: CLARELAY.

Send for CLARE Sales Engineering Bulletins Nos. 120 and 122



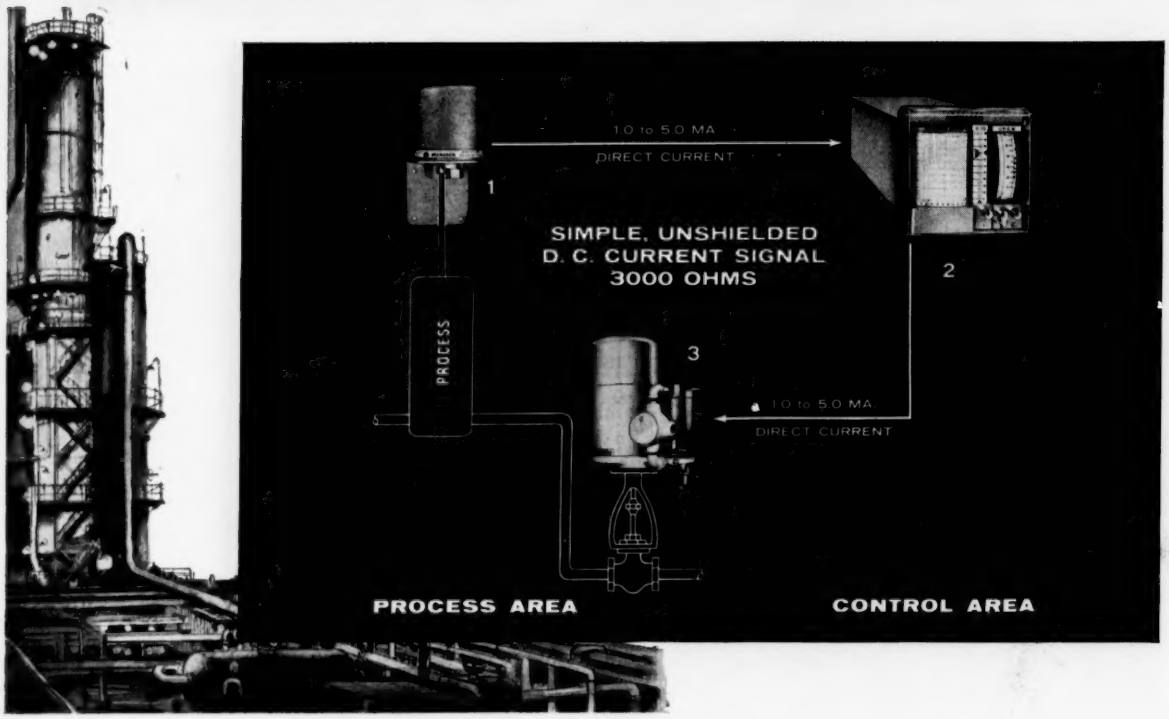
Contacts of CLARE Mercury-Wetted Contact Relays are constantly renewed. By capillary action, like that of a lamp wick, a new film of mercury coats each contact with every make and break.



Drawings (left) from high-speed photographs show the cycle. (a) Filament of mercury forms between the contacts as they separate. (b) This becomes narrower in cross section and (c) finally parts at two points, allowing globule of mercury to fall out. Mercury flows up the capillary path, replaces amount lost, restores the equilibrium. (d) The momentary bridging of the parting contacts—and the extremely fast break that ends it—minimizes the arc and adds greatly to contact load capacity. Contact closure between the two liquid surfaces bridges mechanical bounce and prevents any chatter from appearing in the electrical circuit.

CLARE RELAYS

FIRST in the industrial field



Let's look at a typical control loop of the 'American-Microsen' *ELECTRONIC PROCESS CONTROL SYSTEM*

This all-electronic dc system of miniature-type units assures the instrument engineer of 1) better control; 2) greater flexibility; 3) lower initial costs; 4) lower operating costs. The typical control loop above demonstrates the simplicity and functions of the system.

1. Transmitter. 'American-Microsen' transmitters are used for measuring pressure, temperature, differential pressure, liquid level, flow, and other process variables. The "Microsen" balance creates a stable dc signal for long distance transmission. Transmitters have no bearing pivots or linkages — assuring sensitivity and repeatability of measurement. Small size is made possible by printed circuitry and miniaturized components. The unit can be installed on meter piping, pipe pedestal or vertical surface.

2. Controller. A single unit combines all functions of measuring and recording or indicating the input signal; producing the control signal; and allowing manual-automatic process operation. Separate plug-in chassis provides the following functions: *A.* Records or indicates process variable. Strip or card chart recorder chassis available. *B.* Produces proportional, reset and rate control actions to regulate the variable. All control settings are calibrated. *C.* Permits switching to manual operation during start-up or emergency conditions, with true "bumpless" transfer from manual to automatic control.

Transistorized design increases reliability and service life. Miniaturization and consolidation of control functions reduces panel cost and wiring expense.

3. Electro-Hydraulic Control Valve Operator. A power unit with position feedback that operates slip-stem control valves. No compressed air is needed. Mountable on standard yokes supplied with conventional slip-stem control valves with bodies of single or double-seated construction, with V-port, parabolic, needle and equal percentage plugs, including valves of 4" stroke, and force available up to 3,250 lbs.

Where required, the American-Microsen Electro-Pneumatic Valve Positioner or the Electro-Pneumatic Transducer can be supplied.

In automating your processes for higher product quality and greater operating economy, you want the better control and simplified servicing provided by the American-Microsen Electronic Process Control System. We invite you to meet with one of our sales engineers to determine the best equipment for your service. Write for literature.

MANNING, MAXWELL & MOORE, INC.

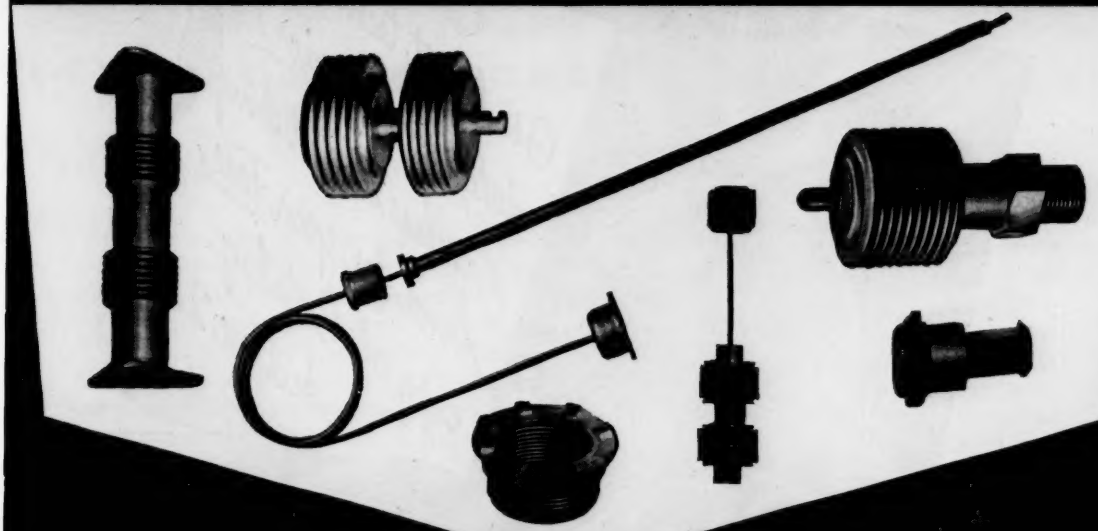
MANNING MAXWELL & MOORE INC. TRADE MARK

INDUSTRIAL CONTROLS DIVISION • STRATFORD, CONNECTICUT

MAKERS OF 'AMERICAN-MICROSEN' ELECTRONIC INSTRUMENTS FOR MEASUREMENT, TRANSMISSION AND CONTROL

For more information circle **51** on inquiry card.

HOW TO SAVE TIME AND MONEY ON COMPLETE BELLOWS ASSEMBLIES



No matter why or how the bellows principle enters into an assembly, Fulton Sylphon can assemble the right bellows and related accessories or mountings into a complete device that meets your specifications. In doing this Fulton Sylphon offers important design help, specialized skill in joining bellows with other members, and modern production facilities for on-time deliveries.

BELLOWS FOR INSTRUMENT ASSEMBLIES

are available with diameters, lengths, strokes, spring rates, metals and charges to provide a wide range of movements in high or low pressure systems. In all applications the exclusive Sylphon® bellows assures continuing accuracy and safety of operation. For one thing, cold-working production methods give it maximum resiliency for withstanding repeated cycling. In addition, its *seamless* design and the availability of multiple plies enable the Sylphon bellows to better resist pressure and other conditions.

Send for Bellows Catalog 1400-NL

Mr. Controls

Robertshaw-Fulton

CONTROLS COMPANY

FULTON SYLPHON DIVISION, Knoxville 1, Tenn.

For more information circle **52** on inquiry card.

ENGINEERS... DESIGNERS... P.A.'S

Get latest technical data on Superior stainless small tubing
Send for your free copy of Catalog Section 21
CATALOG SECTION 21
Superior Tube
STAINLESS STEEL TUBING

This invaluable reference guide is yours for the asking! A really *big* catalog, handsomely bound—each page is crammed with important technical information on a wide variety of stainless analyses. There is specific information on each analysis, including its physical and mechanical properties, and data on its corrosion and heat resistance. A special section covers Superior's "super alloy" tubing for aircraft, missiles, etc. Pages are devoted to the selection and application of stainless tubing. Separate sections cover soldering, welding, machining, bending, etc. All this and much, much more! Get your copy while our supply lasts!

Superior Tube
The big name in small tubing
NORRISTOWN, PA.

All analyses .010 to ⅜ in. OD—certain analyses in light walls up to 2½ in. OD

West Coast: Pacific Tube Company,
5710 Smithway Street, Los Angeles 22, Calif. • RAymond 3-1331

SUPERIOR TUBE COMPANY
1968 Germantown Ave., Norristown, Pa.

Rush me my free copy of your Catalog Section 21.

Name_____ Title_____

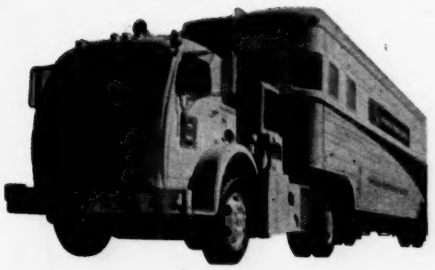
Company_____

Address_____

_____

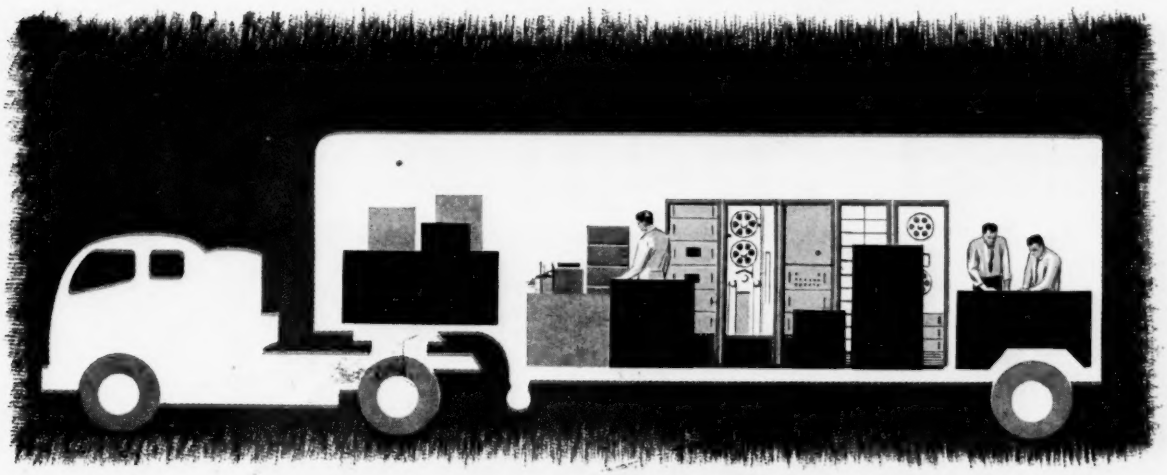
For more information circle **53** on inquiry card.

Best solution for high-speed flexibility



Put your data-processing lab on wheels

These Trailer Labs—designed and built by Consolidated's System Division—soon will be delivering fast, on-the-spot test data for several aircraft companies. Buyers know that the only efficient location for a data-processing center is at the site where the work is being done. CEC solved this problem with an efficiently designed, integrated system custom-built to do a precision job anywhere. Raw data can be introduced in the form of analog information which is processed at high speed to digital form as punched cards or tabulated summary sheets. Your company can profit with this high-speed flexibility. Let CEC's System Division show you how quickly a custom-designed Trailer Lab pays for itself. Contact your CEC field office for complete information.



Your company can take advantage of this convenient high-speed system...and at no extra cost. For proof, contact your nearby CEC field office, or write for Bulletin CEC 1304-X43.

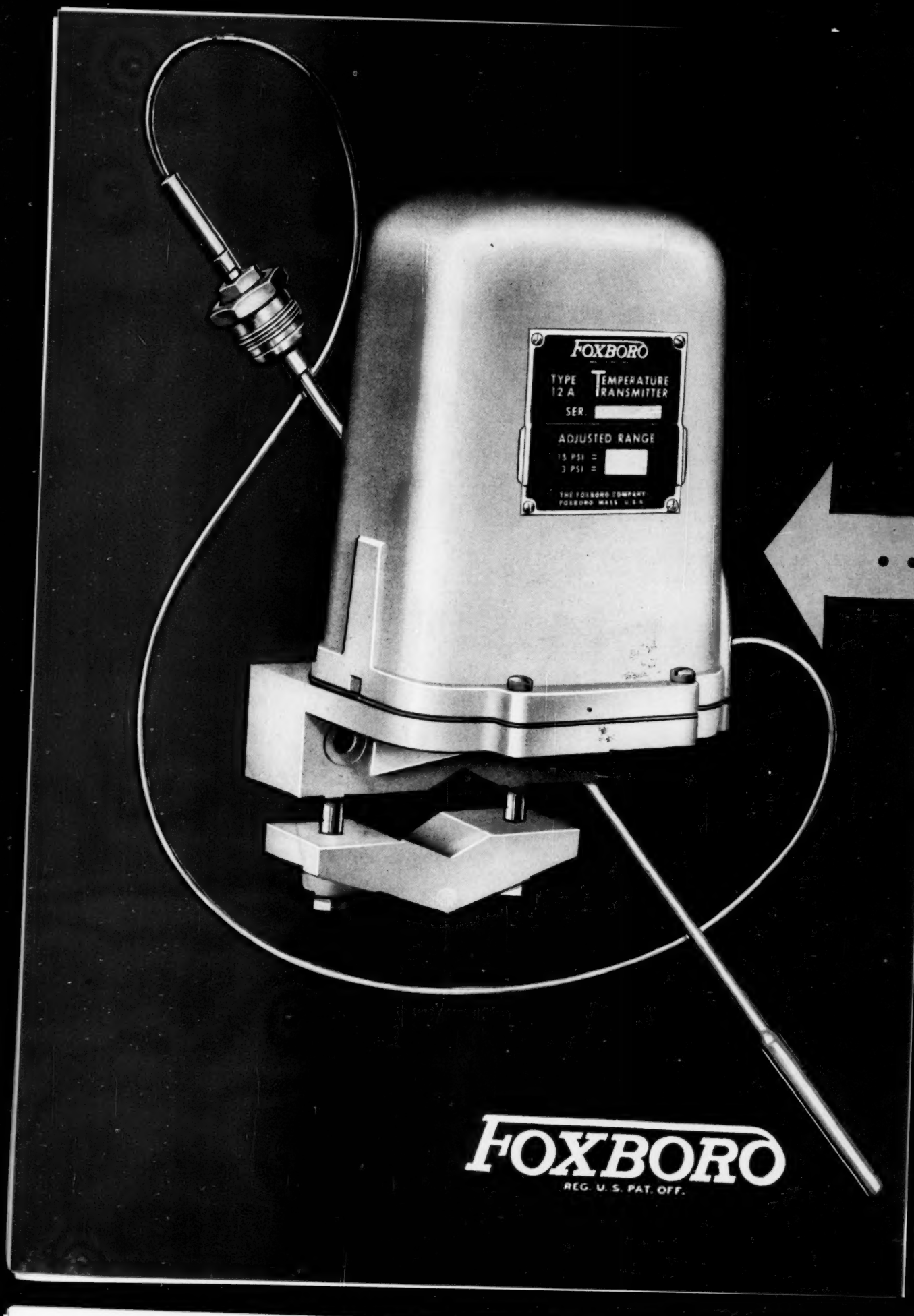
Systems Division

Consolidated Electrodynamics

300 North Sierra Madre Villa, Pasadena, California

OFFICES IN PRINCIPAL CITIES THROUGHOUT THE WORLD

For more information circle **54** on inquiry card.


FOXBORO
TYPE 12 A TEMPERATURE TRANSMITTER
SER.
ADJUSTED RANGE
15 PSI =
3 PSI =
THE FOXBORO COMPANY
FOXBORO MASS U.S.A.
FOXBORO
REG. U. S. PAT. OFF.

Type 12A pneumatic

Temperature Transmitter Improves Remote Control

. fast — sensitive — rugged!

There is no easier, simpler way to measure remote temperatures, over so wide a range, with such high sustained accuracy and speed, and at so low a cost!

The Type 12A Temperature Transmitter converts temperature measurements to a linear air output signal, which is transmitted to any standard 3-15 psi recorder or controller. Measuring spans of 50, 100, 200, or 400 degrees F. are available, set as required within the over-all transmitter range of −100°F (lower when necessary) to +1000°F. Fully compensated for ambient temperatures and pressure, this rugged, highly responsive instrument performs outstandingly under the most severe conditions. And it's insensitive to mechanical vibration.

The transmitter weighs only 7 pounds with its integral mounting bracket. It can be mounted anywhere . . . in any position . . . even directly on a bulb socket! The gasketed, weatherproof housing permits installation in any hazardous, corrosive, or outdoor location. Transmission line is conventional air tubing — no troublesome conduit, no costly capillary to run.

Derivative action is furnished for optimum performance when process or transmission lags exist.

Write for Bulletin 13-17. It explains fully why the Foxboro Type 12A Temperature Transmitter gives better performance with lower installation and maintenance cost. **The Foxboro Company, 467 Norfolk St., Foxboro, Mass., U.S.A.**

Pneumatic Temperature Transmission

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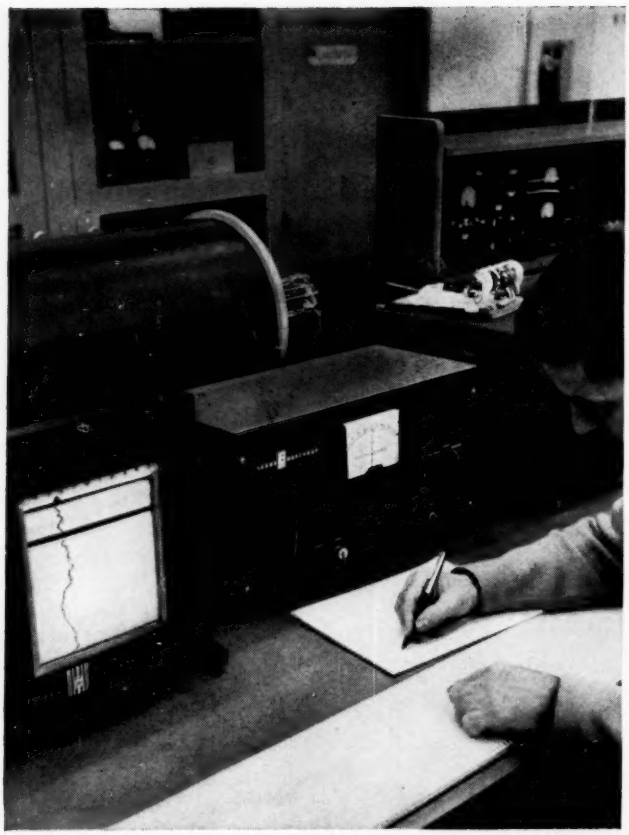

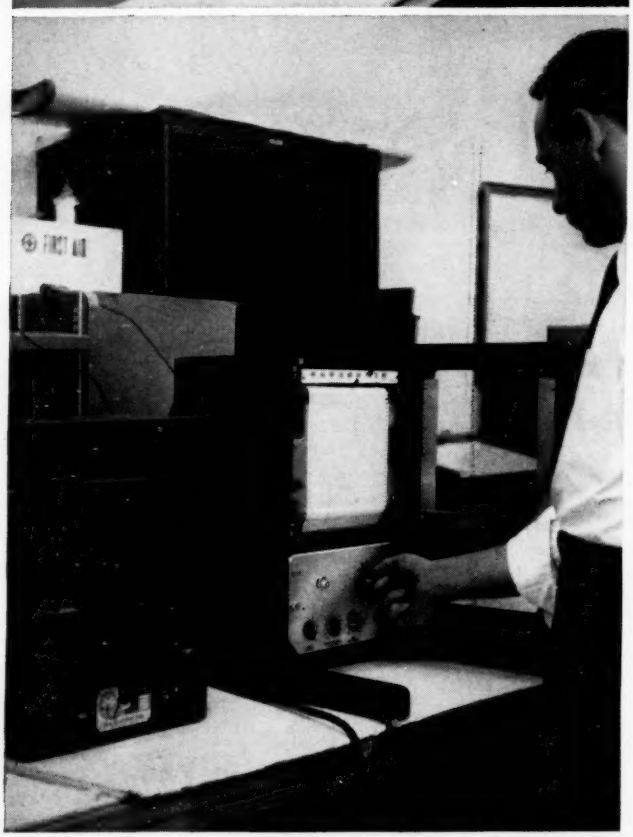

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INSTRUMENTS and AUTOMATION

AUTOMATION: The use of devices—mechanical, pneumatic, hydraulic, electrical and electronic—for making automatic decisions and efforts.—*M. H. Aronson*, Editor

Editorial

Management Asks Questions

DESPITE the mass of written material extolling instrumentation and automation, despite the glorification, sometimes approaching deification, of "automation," despite the attention of an entire nation, the executive of a manufacturing operation still asks his engineers for specific answers to the following questions: "Why use instruments? Why spend money on instrumentation? Why are instrument costs higher in your plant A than in plant B?"

Our industry rests on an honest, complete, and authoritative answer based on facts, not opinions or generalities.

Professor James Bright of Harvard University recently reported on the benefits of automatic control and instrumentation, as established by a detailed study of 13 manufacturing operations, including process plants and manufacturing factories (see *I&A*, Feb., 1957, pages 249-51). Table 1 from his report is given here.

Note that 22 beneficial results are reported by actual users of instruments and automation. These are the primary 22 answers to the first question.

Note also the secondary and unexpected benefits. This characteristic of instrumentation and automatic control is a unique and important fact. In almost all instances indirect and unexpected benefits accrue to the plant that uses automation—mechanical, pneumatic, hydraulic, electronic, and electrical means for automatic measurement and control of its operations.

Such indirect and unexpected benefits are difficult to predict and often are overlooked in evaluation of a cost situation. A new piece of process equipment has an obvious and easy-to-establish cost and immediate effect; the many varied benefits to be derived from instrumentation are not as easy to pin down on a cost-vs-result ledger. But they are there, as established by actual case histories.

In addition to the 22 operational benefits listed, several analytical reasons of equal, if not greater, significance exist for using instrumentation. These reasons apply specifically to instrumentation applied to the problems of finding out *why and how the operation can be improved*, as contrasted with the instruments and equipment actually monitoring, controlling, and operating the process. Such instrumentation—data handlers, recorders, analog computers, etc.—is not operational; it is basically analytical. The bene-

Table I—Motives and Benefits of Automation in 13 Firms

Characteristic	Number of Plants Experiencing This Characteristic As		
	Primary Motive	Secondary Objective	Unexpected Benefit
Increased capacity	11	2	
Reduced direct labor content per unit of output	12		
Reduced indirect labor	8		3
Shorter lead time	2	1	3
Higher quality of product	8	1	2
Reduced scrap	1	2	7
Increased Equipment Utilization	2		2
Ability to expand production without major work force increases	1		
Improved safety	1	3	1
More attractive working conditions	1	2	5
Easier production control job		1	2
Easier plant administration		3	
Lower maintenance cost	1	1	1
Lower capital investment	1		
Increased Flexibility in products manufactured	1		
Less skill and training required of some workers		1	5
Shorter setup time			2
Reduced floor space requirements		2	2
Reduced work in process inventory	1		
Easier housekeeping	1		6
Reduced insurance cost		2	
Sales promotion value of new plant			3

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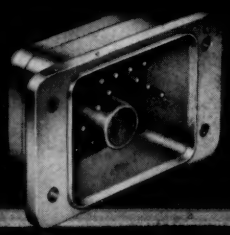

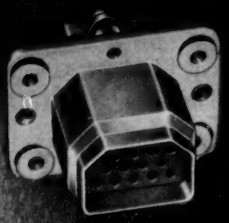

Cannon offers you more than 18 different basic designs in [illegible] chassis connectors... designed with all the latest features to give accurate alignment, easy mating, proper connection, and [illegible] sealing where desired.

Select the connector you want in standard, miniature, or sub-miniature sizes... for standard circuitry or printed circuitry. Up to 156 contacts... and a great number of combinations of contacts for control, audio, thermocouple, co-ax, twin-ax, and pneumatic connections. In single- or double-gang. Some with shells, some without... all ruggedly constructed to take the many "in" and "out" operations of rack, panel, chassis, and sub-assembly applications. Special moisture-proof types. Standby units featuring gold-plated contacts to withstand deterioration and corrosion.

For an interesting discussion of the broad subject of "Reliability," write for Cannon Bulletin R-1.

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CANNON PLUGS

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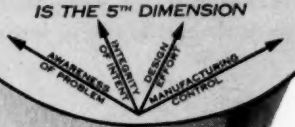


EDITORIAL—CONTINUED

fits to be derived from this type of instrumentation are:

1. Establishment of the factors now limiting the production process in efficiency and production.

2. Accelerated modification of processing and control equipment to increase productivity and efficiency.

3. Preparing the way for rapid acceptance of the newest production techniques, as they emerge.

4. Accelerated transformation of the production process from an "art" into a "science," removing the dependancy on nontransferable human instinct.

These four analytical reasons will be recognized by progressive management as being vital to the process of evolutionary progress via innovation and change, change based on hard technical insight. They will be recognized also as cost items whose returns can not be stated with accuracy.

With this factual background in mind, let us return to the specific questions that management asks.

"Why use instruments?" The 22 operational reasons tabulated and 4 analytical reasons mentioned are in an approximate order of relative importance, based on actual case histories.

"Why spend money on instrumentation?" Several of the benefits derived from instrumentation are immediate and direct; some of the plant operations would become inefficient, dangerous, intolerably routine, or even impossible without the instrumentation. Although it is clearly not feasible to delineate the exact amount of all indirect benefits, their total effect is reflected in the plant operations and competitive situation.

"Why does Plant B spend less than your Plant A on instrumentation?" Either Plant B is a simple uniform-product self-regulating-type operation—or its engineering staff is *not* analyzing its operations, automating its repetitive operations, and preparing for the even more exciting (and costly) instrumentation that will be available in the near future.

Appraisal of the many direct and indirect benefits to be realized from automatic measurement and control, in light of the rapid rate of technical change and analytical techniques, thus casts instrumentation in a new light. The questions that progressive management should ask of its engineering staff are now:

"Are you using as much instrumentation as you should?"

"Why are your instrument costs in Plant B less than those for Plant A?" MHA

European Survey Planned

RICHARD RIMBACH, publisher of *Instruments and Automation, Instrument & Apparatus News, Military Automation,* and numerous books in the instrument field, has arranged for a European survey and study tour of instrument and automation developments to be taken by leading American authorities, Oct. 27-Nov. 13.

The group will depart from New York City October 27th and return to New York November 13th.

This proposed itinerary is subject to slight changes when final travel accomodations are checked.

Cost of the tour will be between $1000 and $1400 per person, including plane fare, meals, and hotel. Leading instrument manufacturers and users, and their wives, are invited to join this group, which will be limited to 25 persons.

If you are interested in joining the tour and want additional information, contact Richard Rimbach, 845 Ridge Ave., Pittsburgh 12, Pa., Telephone Fairfax 1-9831.

Tentative Itinerary:

October 27 Leave New York City by air Sunday evening.

October 28-29 In London: Meetings with American diplomatic officials and prominent British instrument manufacturers and users (members of the British Industrial Measuring and Control Apparatus Manufacturers' Association and the Society of Instrument Technology). Individual meetings can be arranged. Time not needed for business contacts can be used for sightseeing or shopping. Leave for Brussels by air.

October 30 In Brussels: Meetings with business leaders, officials of the Brussels World Fair scheduled for 1958 and with the officers of the Association Internationale de Cybernétique.
Leave for Milan by air.

October 31-November 1 In Milan: Meetings with American commercial attachés and prominent Italian instrument manufacturers and users (members of the Associazione Nazionale Industriali Dell'ottica, Meccania Fine e di Precisione, and the Associazione Nazionale Italiana per l'Automazione).
Brief sightseeing tour of Milan.
Leave for Duesseldorf by air.

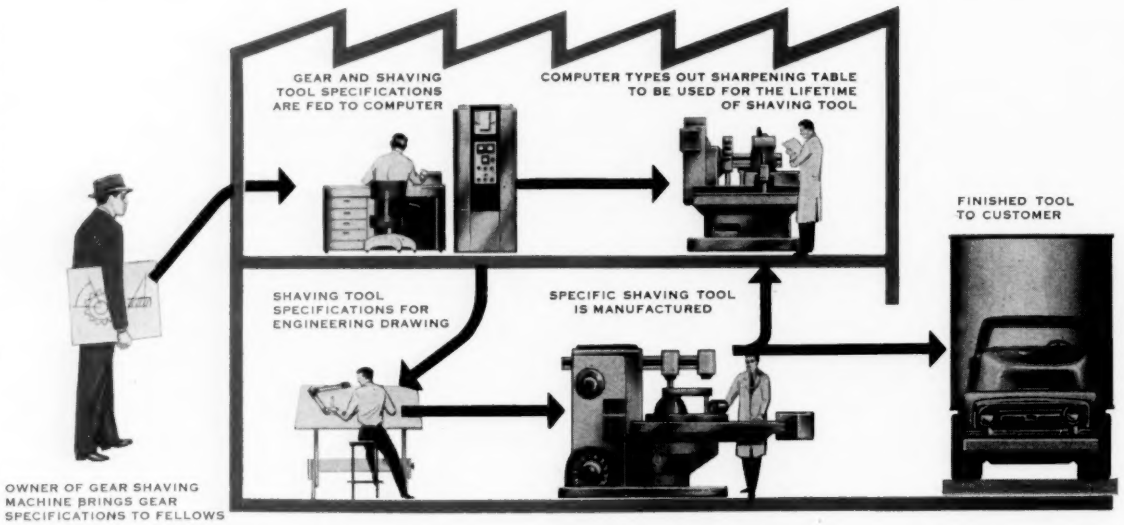
November 2-8 In Duesseldorf: Attendance at the technical sessions and exhibits of the Internationaler Kongress mit Ausstellung fuer Messtechnik und Automatik. Meetings with German instrument manufacturers and users (members of the Verband der Deutschen Feinmechanischen und Optischen Industrie; Fachgemeinschaft Pruefmaschinen; and the Normenarbeitsgemeinschaft fuer Mess— und Regeltechnik in der Chemischen Industrie).
Visit to chemical plant. Sightseeing and shopping. Leave for Paris by air.

November 9-12 In Paris: Meetings with representatives of French and American commercial and scientific attachés and prominent French instrument industry representatives (members of the Chambre Syndicale des Fabricants d'Appareils de Regulation et de Controle Industriel; the Syndicat General de l'Optique et des Instruments de Precision; the Syndicat de la Robinetterie; the Federation Francaise de Syndicats Nationaux de l'Industrie de la Mécanique de Haute Precision; and the Chambre Syndicale des Constructeurs des Compteurs, Transformateurs de Mesure et de Controle).
Sightseeing and shopping.
Leave for New York

November 13 Arrive in New York

Circle 57 on inquiry card.

Fellows Gear Shaper Co. designs tools 22 times faster with a Bendix Computer


GEAR AND SHAVING TOOL SPECIFICATIONS ARE FED TO COMPUTER
COMPUTER TYPES OUT SHARPENING TABLE TO BE USED FOR THE LIFETIME OF SHAVING TOOL
FINISHED TOOL TO CUSTOMER
SHAVING TOOL SPECIFICATIONS FOR ENGINEERING DRAWING
SPECIFIC SHAVING TOOL IS MANUFACTURED
OWNER OF GEAR SHAVING MACHINE BRINGS GEAR SPECIFICATIONS TO FELLOWS

problem:

For many years, Fellows Gear Shaper Company designed gear shaving tools and cutters for its customers by the same method—extensive layouts combined with manual calculations. A faster and less expensive method was needed.

solution:

In 1955, Fellows turned this problem over to its new Bendix G-15 Digital Computer. Now, gear and shaving tool specifications for each order are typed into the computer. In a matter of minutes all information needed for manufacturing drawings is computed and typed out. The G-15 also generates a sharpening table good for the life of the tool. Pricing tables are prepared automatically and all designs are indexed and recorded on magnetic tape to prevent duplication of engineering work on future orders. Time saving on tool design alone averages 2200%.

Many companies engaged in manufacturing have found ways to lower costs and provide better service by putting the Bendix G-15 to work. A report on how Fellows is cutting costs while cutting gears is available. It contains many valuable ideas. Mail the coupon for your copy.

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PROCESS INSTRUMENTS

New HP-30 Pyrometer provides ±.5% accuracy, automatic lead length compensation, and features printed circuits

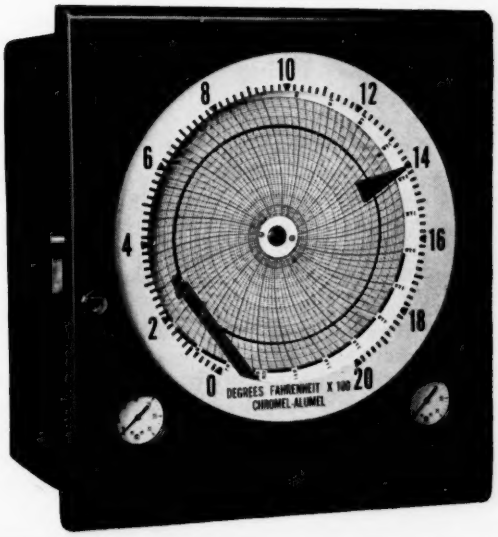
PRINTED CIRCUITS AND MINIATURE COMPONENTS mean a smaller pyrometer (new size: $7\frac{9}{16}$ inches x 8 inches) and savings on valuable panel space.

AUTOMATIC LEAD LENGTH COMPENSATION up to 25 ohms in low ranges and 90 ohms in higher ranges is an exclusive feature on the new HP-30 Pyrometer.

±.5% ACCURACY AND .1% TO .5% SENSITIVITY MAINTAIN THE HIGH ACCURACY and close sensitivity associated with General Electric pyrometers.

NEW INTERCHANGEABLE CONTROL FORMS, including the all-electronic time-proportioning control, allow maximum flexibility.

HE Recorder-Controller gives ±.25% accuracy, continuous standardization, has widest ambient operating range



CONTINUOUS STANDARDIZATION provides an unchanging reference for close control and lower maintenance, through the elimination of dry cell, standard cell, and conventional standardizing circuit.

HIGHER ACCURACY REFERENCE JUNCTION provides measurement accuracy unaffected by changing ambient temperatures.

REMOTE TRANSMISSION of signal from recorder is available at no additional cost.

WIDEST AMBIENT OPERATING RANGE from 0 to 125 F.

ALSO AVAILABLE are a-c bridge recorders and multi-point precision indicators, pneumatic or electric control, electric programming control and sensing devices for measuring temperature, pH (acidity), power, speed, and other variables for continuous process industries.

FOR FURTHER INFORMATION, write to Section 587-10, General Electric Co., Schenectady 5, N. Y. for your free copies of bulletin GEC-1377 (HE RECORDER-CONTROLLER) and bulletin GEC-1449 (HP-30 PYROMETER). Or you can contact your nearest General Electric Apparatus Sales Office.

GENERAL ELECTRIC

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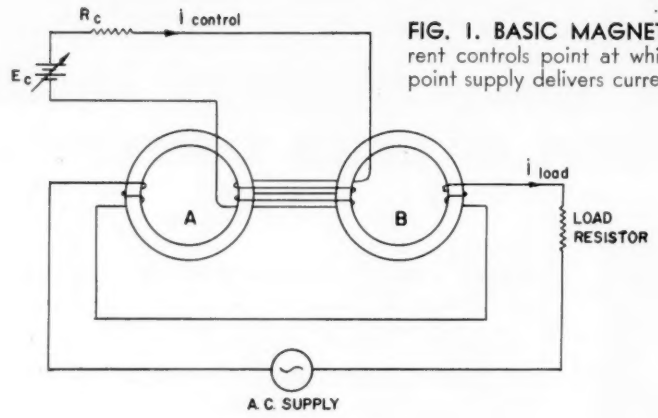


FIG. 1. BASIC MAGNETIC AMPLIFIER. Control current controls point at which reactors saturate, at which point supply delivers current to load.

J. A. BARING

Norwood Controls Unit
Detroit Controls Corp.

Solid-State Amplifiers

MAGNETIC AMPLIFIERS usually use d-c input to control a-c output (Fig. 1). The *control winding* links toroids A and B. The *load* (resistor) is in series with the a-c supply and with other windings on the toroids. Whether the supply current can reach the load depends on the inductive reactance of the toroids, which is in turn controlled by the control current.

Fig. 3 shows the hysteresis loop for an idealized square-loop magnetic material. Only the rectangular part of the loop is traversed during the condition of zero control current—that is, the toroids are not saturated in either direction. Under such conditions the impedance of the output winding is very high, resulting in a negligible value of load current. When not saturated, the toroids act like an open switch in the output circuit, preventing the supply current from reaching the load.

As soon as current is injected through the control winding, the midpoint of the hysteresis-loop swing is shifted, permitting the a-c supply to saturate the loop at one end or the other. Once into saturation the inductance in series with the load drops nearly to zero, thereby effectively closing the circuit in series with the a-c supply and load resistor. The result is a large load current switched on at the point of saturation. This point is controlled by the level of the control-circuit current.

Fig. 4 shows the load current at an intermediate level of control current. During the angle alpha the cores are unsaturated and effectively present an open circuit to the supply voltage. When saturation occurs, the load current immediately jumps to a value determined by the load resistance and the supply voltage, and follows the solid curve back to zero. The same occurs on negative half cycle. The solid curve on the flux path shows the hysteresis loop shifted upwards and extending to the right into the saturated region. It can be seen that the action of the magnetic amplifier is similar to a synchronous switch whose relative phase determines the average value of the load current.

Feedback

In Fig. 2, feedback windings have been added to each of the cores. They are supplied through a bridge rectifier in series with the output circuit. Feedback current flows in such a direction as to aid the control current. Most magnetic amplifiers of the conventional variety employ positive feedback in this manner.

Positive feedback greatly increases the *power gain* of the amplifier. It also renders the amplifier polarity sensitive. When no feedback is used, the load current is symmetrical about the zero control-current axis. When positive feedback is added, load current is increased for one polarity of input and decreased for the other. The result is a steep slope in the region of zero control current, which is now polarity sensitive. This increase in gain is bought at the price of poorer frequency response and increased amplifier nonlinearity.

In "mag-amps" of recent design the input and output circuits are decoupled by the use of diodes in such a way that amplifier response occurs within one cycle of carrier frequency, a valuable characteristic when dealing with control systems or servomechanisms requiring rapid response. These units can accept alternating control current, such as is obtainable from a variable-transformer pickup.

It can be seen from the circuit of Fig. 2 that the mag-amp is characterized by a low input impedance because its input is a coil.

Mag-amps are rugged and reliable. Perhaps the limiting factor in life is that of the diodes used. Until recently, the diodes required in the feedback circuit of Fig. 2, or in the high-response-type amplifier, have had a limited life expectancy. Ref. 1 shows the rapid improvement made in the life expectancy of germanium diodes.[1] Fabrication techniques which in-

The electronic-pneumatic debate has an important corollary debate—electron tube vs transistor vs magnetic amplifier. Reliability of magnetic amplifiers makes them attractive for many control-loop applications. This article relates mag-amp characteristics to the special requirements for each control-loop component.

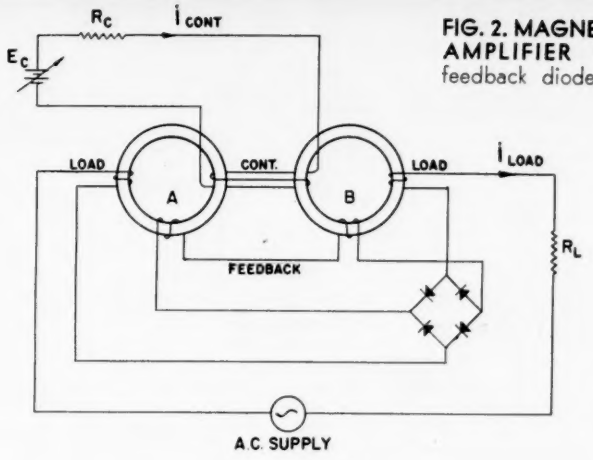


FIG. 2. MAGNETIC AMPLIFIER with feedback diodes.

In Control

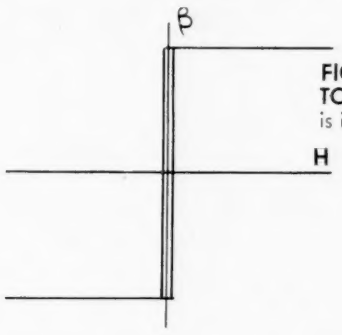


FIG. 3. SQUARE-LOOP TOROID characteristic is ideal.

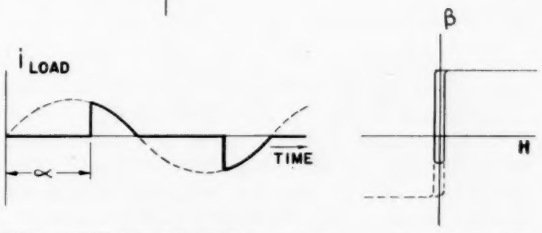


FIG. 4. LOAD CURRENT vs time in a biased toroid.

hibit contamination of the junction have led to 100% survival for a 2000-hour test.

Transistor Amplifier

Functional descriptions of transistor amplifiers are abundantly available. Their attractiveness for application to industrial instrumentation has been enhanced recently by improvement in life expectancy.

Tests on large numbers of medium-power transistors have shown only minor changes in characteristics in 10,000-20,000 hours of operating life, the data given in Fig. 5.

Comparison of Amplifier Characteristics

Fig. 5 compares a typical vacuum-tube stage, a transistor stage, and a 60-cps mag-amp stage. Values are not precise but provide an index of relative performance. The greatest differences between the amplifiers are in input impedance and frequency limits, with the solid-state amplifiers tending to be lower in both instances. The solid-state units excel in life and ruggedness; they suffer from high cost. The mag-amps tend to be larger in size than the vacuum tube; the transistor amplifiers being the smallest. Let us now consider how these features relate to the design of control-loop devices.

Use in Control Circuits

A block diagram of a typical control loop is shown on Fig. 6. Let us examine these units one by one to determine how solid-state amplifiers fit the requirements.

Transmitter

An open-loop-type transmitter having no amplifier is shown in Fig. 7. This form of transmitter implies high reliability. In the pressure transmitter shown, the

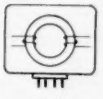
			 60 CPS.
STAGE GAIN	50	30	100
INPUT IMP.	1 MΩ	1 KΩ	.1–10 KΩ
STABILITY	10^{-9} W	10^{-6} W	10^{-8}–10^{-12} W
AMB. TEMP. LIMIT	NONE	150°F. MAX.	250°F. MAX.
TEMP. SHIFT	NONE	SERIOUS	SOME
SELF HEAT	3 W + LOAD	LOAD ONLY	LOAD ONLY
FREQ. LIMIT	100 MC	100 KC	10 C.P.S.
COST PER STAGE	$2–$5	$5–$15	$20–$50
LIFE (1000 HRS.)	10	10–20	40–?
FAILURE	SUDDEN	GRAD.	GRAD.
SIZE PER STAGE	3 IN.^{3}	.5 IN.^{3}	10 IN.^{3}
SHOCK & VIBR.	SHORTEN LIFE	NONE	NONE

FIG. 5. CHARACTERISTICS OF COMPARABLE electronic amplifier components.

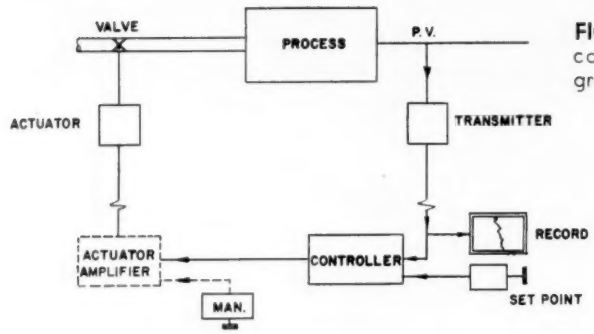


FIG. 6. TYPICAL control-loop diagram.

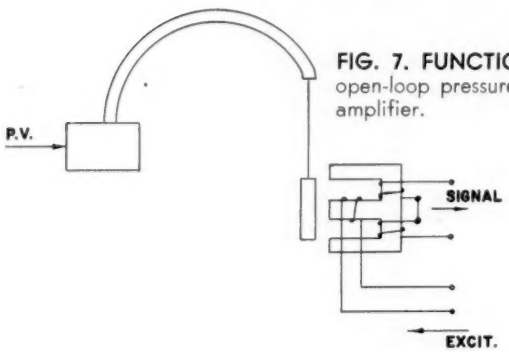


FIG. 7. FUNCTIONAL DIAGRAM of open-loop pressure transmitter, with no amplifier.

FIG. 8. CUTAWAY of transmitter using multipole differential transformer.

process pressure enters from the left and causes the Bourdon tube to deflect a slug relative to the E-shaped differential transformer. The result is a proportional change in the a-c output voltage labelled "signal." The simplicity of such a system can be discerned from the cutaway shown in Fig. 8. In this unit the Bourdon tube is a helical design and the differential transformer is a multipole rotary type. Explosion proofing is easy to achieve.

A solid-state amplifier can be employed with a force-balance transmitter (Fig. 9), again employing a Bourdon tube. Tube motion is converted into a torque on the beam by means of the spring shown. The resulting change in beam position is detected and amplified. The d-c output is then passed through a coil in a magnetic field to rebalance the input force. From there it flows in a series circuit to the load (not shown in the diagram). Separate excitation may or may not be required for the amplifier.

The input impedance, gain, and frequency response of the solid-state amplifier presents no particular problem for its use in the *transmitter loop*. For explosion proofing, the magnetic amplifier is too large to be convenient. The transistor amplifier, whose size is ideal for such service, suffers from the temperature limitation. The open-loop-type transmitter has neither drawback but requires four wires.

Indicator-Recorder

Almost all types of indicator-recorder servos can be described by the general block diagram shown in Fig. 10. Any difference between the output transducer signal and the incoming process variable signal is amplified and causes a motor unit to correct for non-coincidence. Solid-state amplifiers are eminently suitable for this application. Their gain is adequate. As these transducers can be low-impedance devices, there is no penalty accruing from low amplifier impedance. Units conforming to this pattern are commercially available.

Controller

As shown in Fig. 6, the process variable information from the transmitter enters the controller and is compared with a set-point signal. The controller must be able to provide the derivative, proportional, and integral functions of the resulting error signals. The integral (reset) function, being the most difficult to achieve with solid-state amplifiers, will be the only one discussed here. The other two functions are easily provided.

Fig. 11 shows the schematic of an electric integrating device. Most existing electric controllers have their reset action based on some variation of this fundamental circuit. So long as an error voltage E_e exists, the output voltage E_o will change with slope proportional to E_e. (We will consider its operation only on the basis of steady-state error.) After some time, steady state is reached. As capacitors do not pass dc, we can then imagine the capacitor, C, to be removed from the circuit. E_e feeds into the amplifier through the resistance divider consisting of R and R_a, the amplifier resistance. Hence the low amplifier resistance attenuates the input signal and this attenuation must be made up by a higher amplifier gain. Solid-state amplifiers suffer in this application from their low input impedance. The controller represents the

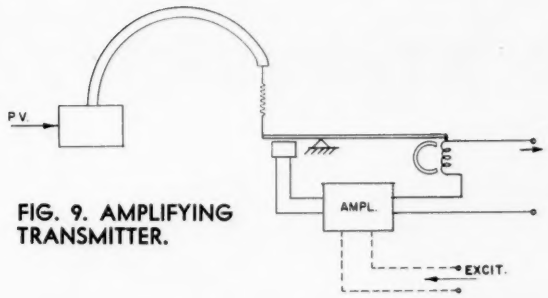


FIG. 9. AMPLIFYING TRANSMITTER.

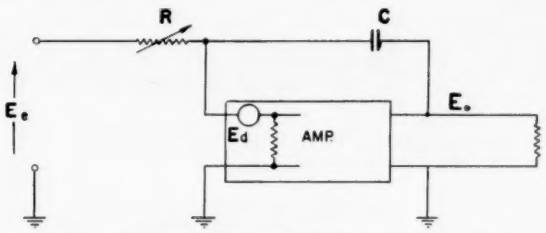


FIG. 11. CONTROLLER WIRING diagram.

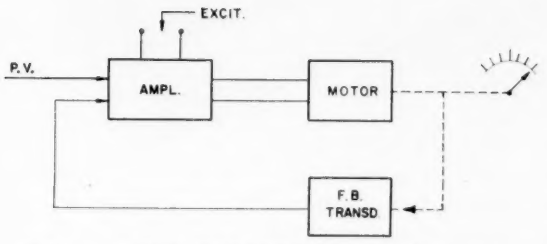


FIG. 10. INDICATOR-RECORDER block diagram.

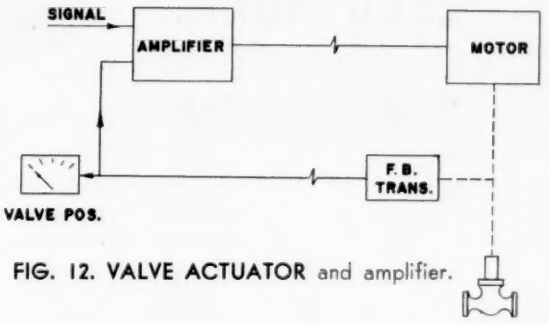


FIG. 12. VALVE ACTUATOR and amplifier.

most difficult application for solid-state amplifiers in the control system.

Valve Actuator

The block diagram for a valve actuator servo is similar in form to that encountered with the indicator-recorder (Fig. 12). The principal difference lies in the power level of the output. Solid-state amplifiers can qualify for such application for the whole job, or as preamplifiers for a relay-type servo. The choice of the servo amplifier depends to some extent on the power level of the signal arriving from the controller. Input impedance, gain, and dynamic response are no limitations to the use of solid-state amplifiers in this phase of the control loop. The amplifying unit is best kept out of areas of high temperature. Transmitting the feedback signal to the control house permits indication of true valve position.

Evaluation

Reliability. Those supporting the use of solid-state amplifiers in control circuits feel that reliability is the prime advantage. This has been true with the advent of better manufacturing techniques for transistors and diodes; ruggedness and insensitivity to vibration have been characteristics of mag-amps from the beginning.

Ease of Maintenance. System maintenance can be made easier if all but the most reliable components are located in the control house. This implies use of the simple open-loop-type transmitter and a valve actuator with local amplification and remote position indication (in the control house).

Performance. Static accuracy of the control system is not limited by the use of solid-state amplifiers. This is in spite of the fact that the controller design is more difficult. The dynamic performance is adequate.

Cost. As no systems are available in complete form, it is only possible to generalize about cost. Solid-state amplifiers are estimated to cost 3 to 10 times more than vacuum-tube types in the low-power sizes. However, the amplifiers represent only a fraction of the total system cost. Reliability features being sought require use of premium components. The resulting price of such a system will probably be higher than its vacuum-tube counterpart; how much higher will depend on whether use of these devices becomes widespread with resulting quantity-production cost reduction.

Reliability is the one feature which, from the users' viewpoint, is worth dollars. One company in the chemical field has estimated that process downtime averages four hours per failure, at an estimated product loss of $6000 per hour. Based on such figures, instrumentation reliability merits a premium price.

Conclusion

It is possible to build control instruments around solid-state amplifiers. With the life of diodes and transistors improved to the present level, these amplifiers already have achieved wide acceptance in military control systems and are sure to fill a need in the process area. Certain elements of the control loop already are available on a production basis; complete systems are soon to appear.

References

1. G. N. Hall, "Case History—Semi-Conductor Rectifier Reliability," *Electronic Equipment*, Jan. 57, pages 36-39.

ELECTRONIC COMMUTATOR

J. F. DAVIDSON
Arnoux Corporation

FLIGHT TESTING modern missiles and aircraft requires transmitting several hundred channels of data by time sharing the telemeter radio link. This new electronic commutator (Series ETC-30) performs the necessary sequential sampling, without use of a mechanical commutator switch with its attendant wiping, wear and noise.

The commutator employs three principal functional circuits: (1) a transistorized pulse generator, (2) a diode switching matrix and (3) a unique counter circuit to switch data channels. It is offered with any sampling rate from 75 to 900 points per second, and meets all IRIG requirements for PAM and PDM commutated telemeter and magnetic tape systems under MIL E-5272A environment. It can be used as a direct replacement for mechanical commutators in 0-3 volt and 0-5 volt systems. Errors due to drift, cross-talk, and nonlinearity are less than 0.50%.

Designed to give noise-free operation without maintenance for 5000 hours, the ETC-30 series features 27 information channels and one master pulse. A built-in limiting feature eliminates necessity for signal limiters elsewhere in the telemeter system. Power required is 150 v dc at 12 ma; size is 3″ dia x 5″ long. Total weight is less than 2 lb.

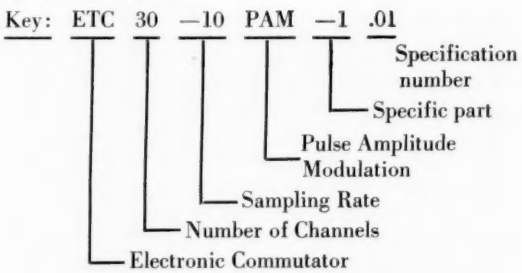
Specifications

Input Signal Characteristics: The electronic commutator shall be capable of commutating input signals with the following characteristics:

(A) Voltage Range—0 to 5 volts dc.

(B) Source impedance—0 to 25 kΩ with proper filtering.

Model Identification:



Output Amplitude: The device shall produce an output pulse train with a peak-to-peak amplitude between 5 volts and 7 volts under the conditions of 5-volt input. Pulse levels corresponding to constant inputs between 0 and 5 volts shall be constant within ±0.5% of full-scale range.

Duty Cycle: The duty cycle in the output pulse train shall be 50 ±3% exclusive of the frame synchronization pulse. The variation in width of the information pulses shall be less than ±5% of the nominal value.

Frame Synchronization Pulse: With an input signal between 0 and 5 volts applied to the frame synchronization channel, the device shall produce a frame synchronization pulse (master pulse) in the output which is equal in width to three "on" periods and two "off" periods. With zero input signal applied to the 27 information channels, the peak-to-peak pulse train amplitude (exclusive of the frame synchronization pulse) shall be between 20% and 25% of the total peak-to-peak amplitude corresponding to 5 volts input.

PRESSURE REGULATORS

for Back pressure— Vacuum — Flow — Pump discharge

C. S. BEARD
General Controls Co.

REGULATORS—NO. 3

The first two chapters of this series dealt with the design of regulators for pressure reduction. Here is a presentation of other types of pressure regulators that regulate upstream pressure (back pressure), vacuum, flow or differential, or discharge of pumps.

REDUCTION OF PRESSURE, which has been discussed in detail, is not the only function of a pressure regulator. Numerous pressure conditions must be controlled, and many control tasks can be accomplished by pressure regulators, often with minor changes in design or use.

Back-Pressure Regulators Control Upstream Pressure

For proper operation, a large number of processes require that a certain pressure be maintained in the system. This may call for a regulator that can be set so that it starts to open at a given inlet pressure. Systems of this kind usually have uncontrollable influx so that a constant pressure can be maintained only by taking some volume out of the system. A flowing oil well is an example for such a system; a fractionating column is another.

The regulator for this application, called a *back-pressure regulator*, consists essentially of the body of a self-actuated pressure regulator which is turned upside down (Fig. 3-1) so that the inner valve *opens* when the *inlet pressure* reaches a certain pressure. Note that this is the reverse of the action of a conventional regulator, in which *outlet pressure* acts to *close* the inner valve. In a back-pressure regulator the upstream pressure (or controlled pressure) acts on the regulator diaphragm to control the inner valve.

Back-pressure regulators perform an altogether different function than a safety valve. The safety valve is required to open rapidly at a given set point so that the pressure in the system cannot exceed some preset value. Its design is such that a reversal of forces exerted against a blow-down ring in conjunction with the area of the seat will hold the valve open until a predetermined reduced pressure is reached. At this point the valve closes abruptly. The back-pressure regulator, on the other hand, attempts to hold a constant upstream pressure by opening up just enough to dissipate sufficient flow to hold this pressure.

Although Fig. 3-1 shows a spring-loaded back-pressure regulator, other types of loading can be used, including variable-pressure loading by means of a pilot, as explained in Chapter 2. Fig. 3-2 shows a pilot-actuated back-pressure regulator. Note that an increase in back pressure will move the pilot plug to bleed pressure from the diaphragm to atmosphere. Fig. 3-3 shows a pilot-actuated piston-type back-pressure regulator. The pilot connection is made to the upstream side of the line (not shown) so that an increase in back pressure (upstream pressure) opens the pilot to increase the pressure on the piston, which in turn opens the inner valve.

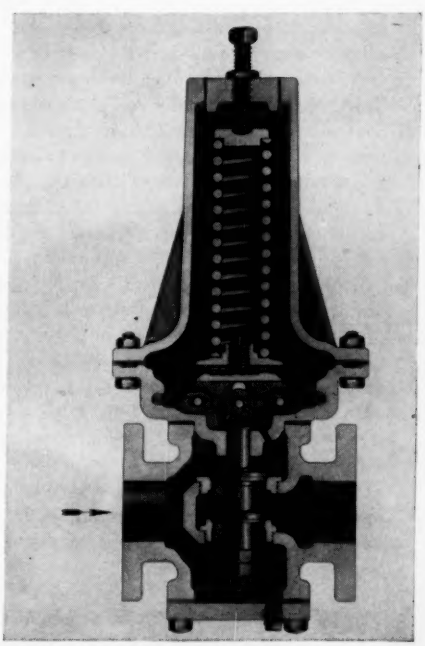


Fig. 3-1. In a basic-pressure regulator, upstream pressure acts to open inner valve, in contrast with the conventional regulator in which downstreams pressure acts to close the inner valve.

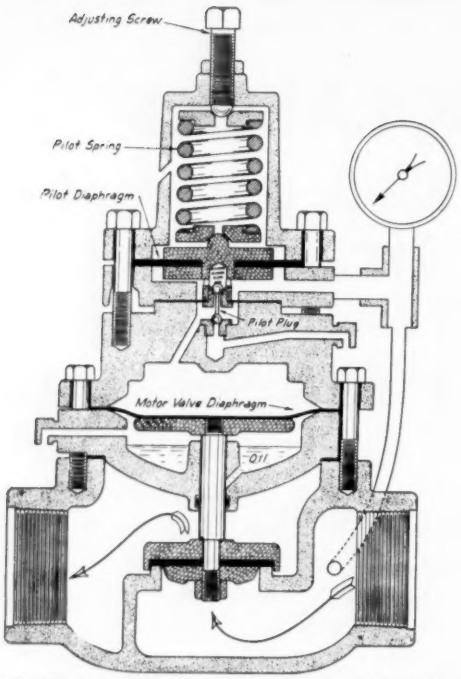


Fig. 3-2. Pilot-actuated back-pressure regulator. Pilot relieves loading to atmosphere to position inner valve.

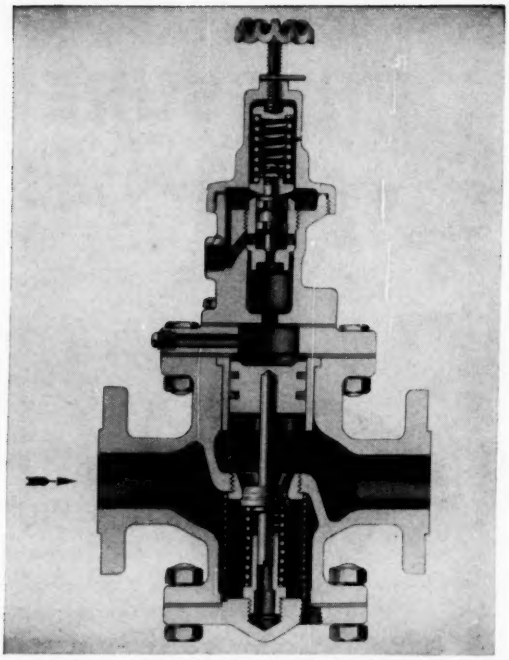


Fig. 3-3. Pilot-actuated piston-type back-pressure regulator.

Vacuum Regulators

Control of vacuum is another form of back-pressure regulation. (Vacuum is a *positive* pressure when referred to absolute zero pressure.) In vacuum regulation the force available to operate the diaphragm is atmospheric pressure. The setting (loading) can be obtained by a spring acting against a diaphragm, or by weights as in Fig. 3-4. The weight acts to open the valve; the vacuum acts to close the valve, aided by atmospheric pressure pushing up on the diaphragm. Pilot systems also can be adapted for this service.

Flow and Differential Regulators

All regulators are basically flow regulators—pressure regulators adjust the flow of line medium, temperature regulators adjust the flow of steam, etc. However, *flow control* implies the maintenance of a preset flow *rate*. This usually requires an instrument-type controller; it is difficult to do a good flow control job without some device, such as an orifice meter, to measure the flow rate. However, flow can be controlled by a regulator that maintains a *constant differential* across an orifice or valve. The differential can be varied for adjusting the flow setting.

This *differential control* can be obtained directly (in relatively small valve sizes and for low pressure-drops) by introducing the two static pressures into the diaphragm case on the opposite sides of the regulator diaphragm, with adjustable effect created by a spring on one side of the diaphragm. For more difficult services, or where the differential pressure is low, the differential can be used to position a pilot valve, as in Fig. 3-5. In a globe valve the weight of the plug might be equal to or greater than the desired differential, a fact which must be considered when selecting the type of valve.

The design of differential valves for emergency shut-off in event of excess flow is interesting and important, but cannot be covered here. For this service many of the valves described can be used with a control system designed to operate the valve under predetermined abnormal changes in flow or pressure. Emergency systems are used also to shut off valves at the well head of a producing oil well in the event of a break in the gathering system.

Most emergency shut-off systems which are based on a change in flow rate are installed in pipelines for the main purpose of sensing a major break in the line. The problem, however, becomes complicated because the differential created by maximum line flow can be as great as the differential caused by a dangerous break.

A common application of a small regulator of the differential type is to control *purge flow* to meter lines, or bubbling rate for a level instrument. Fig. 3-6 shows such a regulator with the low-pressure static line hooked up to the discharge of a rotameter equipped with a needle valve. The purge medium (air, water, nitrogen, caustic, etc.) flows through the rotameter, whose small flow indicates that the purge pressure (out) is slightly above that of the line or tank being purged.

Fig. 3-7 shows a differential regulator with two inner valves (L and F). F is controlled by a bellows and a weight. One side of the bellows is connected to the discharge side of the regulator and the other side is tied in with the discharge of the valve F. In this system the pressure drop across the regulator will be constant and will depend on the weight setting. Further, the flow will be proportional to the setting as dictated by the thermostat.

Flow *characteristic curves* for regulator valves are

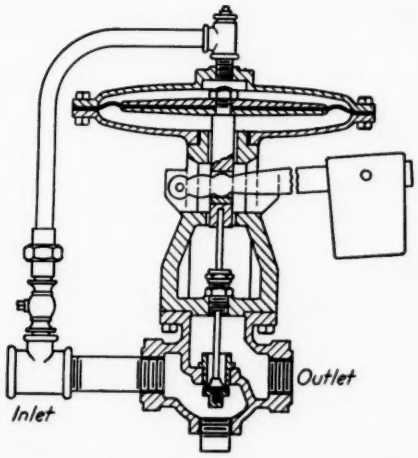


Fig. 3-4. Weights can be used to set a vacuum regulator. The weight acts to open the inner valve; the vacuum acts on the diaphragm to close it.

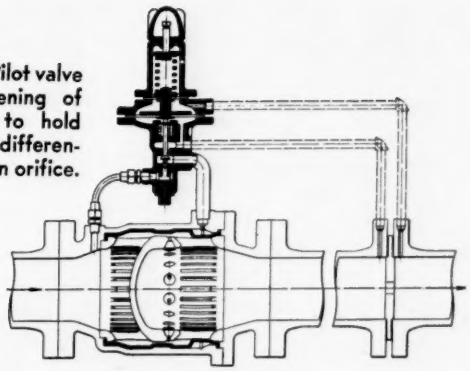


Fig. 3-5. Pilot valve control opening of line valve to hold a constant differential across an orifice.

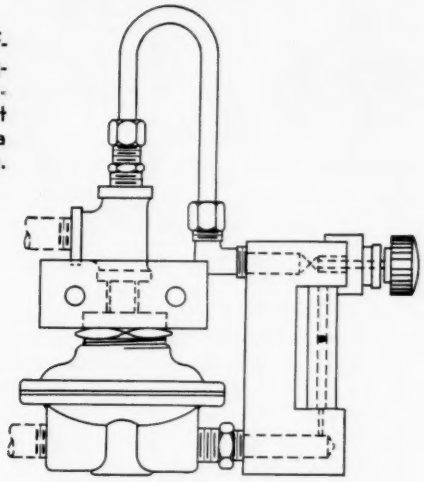


Fig. 3-6. Differential regulator maintains constant small flow to a purge system.

usually drawn with a constant pressure-drop across the valve. The curves would be quite different under operating conditions in which changes in flow through the system would vary the pressure drop. The differential valve shown in Fig. 3-7 reduces variations of the differential so that a desired flow characteristic, as represented by the usual curves, can be maintained.

Differential regulators can be used also to maintain a pressure higher at one point than at another —for example, to operate an injector for mixing or atomizing fuel (Fig. 3-8). When using heavy fuel oil, a recycle flow in excess of the burner requirements is necessary to keep the system clear. Here a differential regulator in the supply line, set to hold an excess pressure above the pressure at a point beyond the burners, will cause a flow greater than the amount being used in the burners.

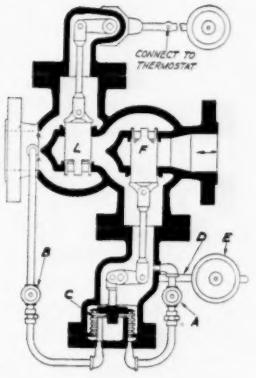


Fig. 3-7. Differential regulator holds desired excess pressure to maintain feed water flow into a boiler.

Pump Governors

The discharge pressure of a pump can be controlled by using various types of regulators, depending on service and type of pump. Discharge from a centrifugal pump can be controlled by placing a pressure-reducing valve in the discharge line, or by use of a valve which relieves excess pressure by controlling recycle flow back to the suction side. Use of recycle flow is not usually used with electrically driven pumps because the power consumption can be decreased by cutting down on the total discharge volume, which is not done when recycle flow is used. However, recycle flow control is popular for reciprocating pumps powered with steam. Even though use of a bypass flow to the suction side uses power it may be necessary to employ this method in order to guarantee a minimum flow through the pump to avoid heating.

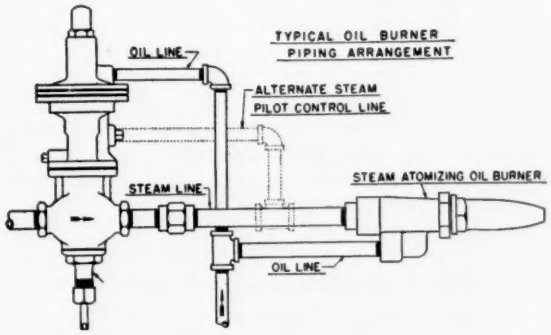


Fig. 3-8. Steam pressure is controlled to stay above oil pressure in order to cause atomization by this differential regulator.

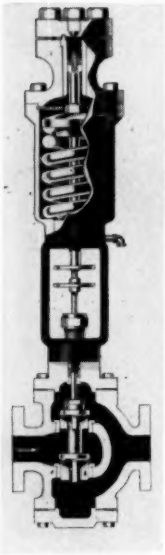


Fig. 3-9. Small piston in pump governor is adaptable for high pressures.

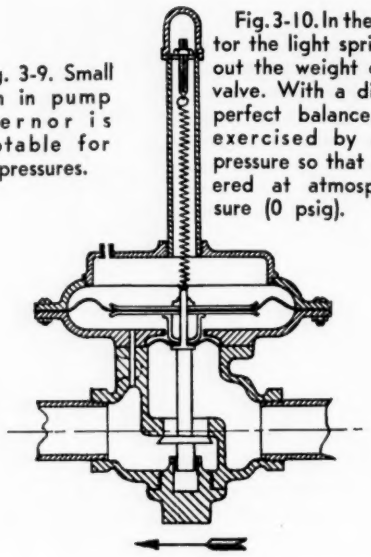


Fig. 3-10. In the zero regulator the light spring balances out the weight of the inner valve. With a diaphragm in perfect balance, control is exercised by atmospheric pressure so that gas is delivered at atmospheric pressure (0 psig).

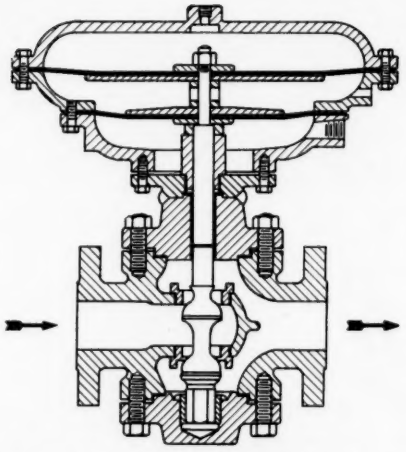


Fig. 3-11. Double-diaphragm balanced regulator permits controlled pressure to be some ratio of loading pressure. Ratio is same as ratio of diaphragm areas.

The third method for controlling pump discharge pressure is to vary the speed of the prime mover. This is done by changing the steam flow to the pump either by a regulator in the steam source or by a diaphragm actuator on the throttle of the prime mover itself. Oddly enough, when a regulator is used to govern the speed of a pump it becomes a pump governor. Here the discharge pressure of the pump is piped to the actuator of a pressure-reducing regulator or to the diaphragm of a pilot which controls the setting of the valve in the steam line.

Pump governors for high discharge-pressures (Fig. 3-9) have a small piston in order to keep the dimensions of the spring within reason.

Zero Regulator

A zero regulator is one that delivers its output at zero (gage) pressure. Although a zero regulator is simply a modified pressure regulator, its application is unique enough to warrant discussion.

Low-pressure combustion systems, in which air and gas are premixed before reaching the burner, require a jet mixer. Air at less than 1-psig pressure is jetted through a chamber, and pulls an amount of gas with it. The gas in this chamber must be at zero gage pressure. The zero regulator (Fig. 3-10) uses a light tension spring to balance the weight of the internal parts. With the top of the diaphragm open to the air, the setting becomes atmospheric pressure. Thus, the inner valve will throttle the flow and deliver gas at atmospheric pressure (0 psig).

Double-Diaphragm Balanced Regulators

Double-diaphragm balanced regulators, such as shown in Fig. 3-11, have numerous uses. The space between the diaphragms is vented to atmosphere; the controlled pressure is applied to one diaphragm, the loading pressure to the other. When the diaphragm in contact with the controlled pressure is smaller than the diaphragm upon which the loading pressure acts, the loading pressure must be smaller than the controlled pressure in proportion to the ratio of the areas of the diaphragms. Reversing the position of the diaphragms reverses the ratio. Application of this equipment allows pressure or fuel control above or below the normal output of a regulator.

The balanced-diaphragm regulator finds application in many instances where the loading pressure is smaller than the controlled pressure in the line. Also, the vented space between diaphragms prevents gas from the line being controlled from seeping into the air loading side; this helps the sealing problem.

Pressure-balanced regulators, whether using single or double diaphragms, are vulnerable to the build-up of high pressures which may be caused by maloperation. An example is the control of burner pressure, a common use of this valve. A bypass valve inadvertently left cracked when the burners are shut off can permit the slow build-up of pressure on the lower side of the diaphragm; this pressure can build up to the full supply pressure to the regulator. As large diaphragms are used in this regulator to gain sensitivity, this abnormal pressure from a cracked bypass valve can exert tremendous forces on the diaphragm case and other parts of the valve.*

Excessive differential across the diaphragm can be limited by a relief valve which discharges to the loading side of the diaphragm, and excessive pressure on the loading side of the diaphragm case can be relieved to atmosphere.

*Manufacturers give maximum pressure ratings on their diaphragm cases. Representative of good design considerations are the factors of safety established by one manufacturer: 8-1 for case strength, 5-1 for case bolting, and 3-1 for strength of internal parts.

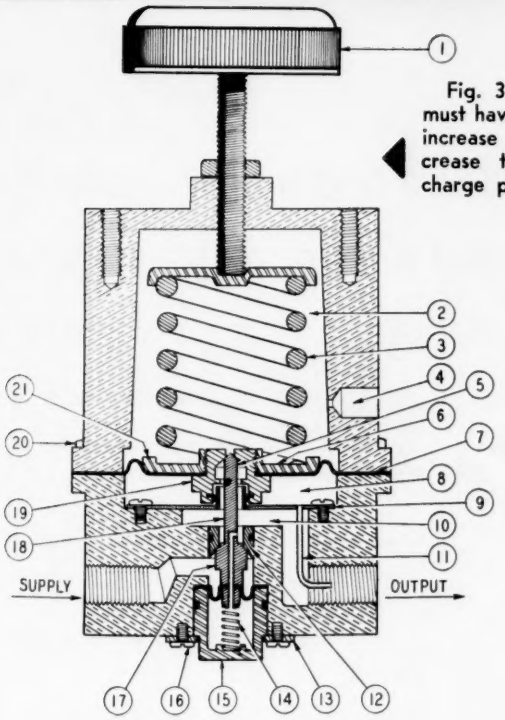


Fig. 3-12. Pilot regulator must have two ports; one to increase and one to decrease the controlled discharge pressure.

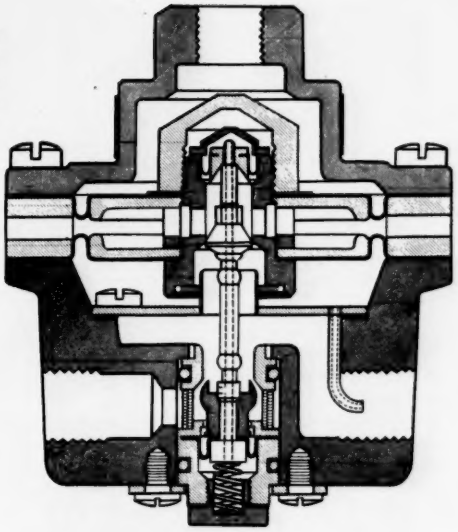


Fig. 3-13. Typical volume booster, or pressure relay, has 1:1 relation between pressure signal in and pressure output.

Pilot and Instrument-Air Regulators

This type of regulators must hold a constant discharge pressure over wide ranges of flow and source-pressure variations. The regulator is used commonly to load pressure-loaded regulators, for positioning a valve (or other piece of equipment) against a calibrated spring, or for supplying instrument air to controllers. For these applications the regulating ability must be high.

The regulator must perform two tasks—(1) reduce the high-pressure source (usually air) to a desired value, and (2) relieve any increase in the controlled pressure above that desired back to the desired value.

To do this the inner valve must operate two ports (Fig. 3-12)—a delivery port (17) and a bleed port (5). When the output pressure decreases, the spring will move the diaphragm down, closing the bleed port and opening the delivery port, resulting in an increase of flow and a buildup of output pressure. When the output pressure increases (or if the setting of the regulator is reduced), requiring bleeding air from the system, the diaphragm moves up, seating the delivery port but separating the bleed port seat from the bleed valve. This results in bleed of air to atmosphere through the exhaust slot.

This type of regulator is made with a fine thread on the spring-adjusting screw, which acts as a vernier for close pressure adjustment.

Closer control of the output pressure under varying flow rates is obtained by using a venturi tube (or what might be called a trailing static pipe) as shown in Fig. 3-12. This is the only access to the diaphragm chamber. An increase in flow tends to exaggerate the attendant drop in pressure over the effect which would be caused if there were no barrier between the diaphragm and the flow stream. This exaggerated drop in pressure causes the valve to open abnormally wide and tends to increase the speed of pressure recovery as well as the accuracy of pressure control. This isolation of the diaphragm chamber also decreases the effect of pulsation in the system upon the movement of the inner valve; the added small chamber and spring (14) at bottom also increases stability.

Pressure Relays

A pressure relay (volume booster) is a form of regulator used to increase or decrease pressure by a set ratio, or to supply a large volume at a pressure equal to the operating pressure. As shown in Fig. 3-13, it is a type of balanced-diaphragm regulator. The controlling pressure is usually the signal from a controller. By bringing an external pressure medium (air in most cases) to the inlet, a much larger volume of discharge can be obtained than would be discharged from the small relay used in the controller, with no loss of pressure. The relay may be installed adjacent to a pneumatic actuator to decrease transmission lag and to increase the speed of loading the actuator. The output pressure of a booster is usually equal to the controller output—that is, the output pressure of the volume booster is usually the same as the signal input pressure—but it can be varied between a ratio of 1:6 and 6:1.

Most of the variations in regulators are not so much variations in design as they are diverse applications of available types of regulators in combination with pilots and relays. The gas industry employs a wide and ingenious variety of these combinations to obtain overriding emergency control and varying pressure control based on time of day, ambient temperature, or gas consumption. Each industry has its own unique uses for the basic designs that have been reviewed.

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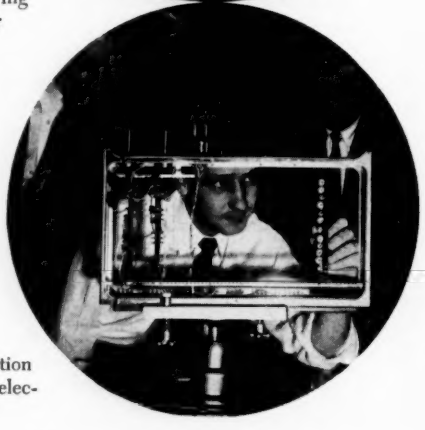

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SPECIAL ENGINEERING PRODUCTS • TIME EQUIPMENT

Plants and laboratories: Endicott, Kingston, Owego, Poughkeepsie, N. Y.; Lexington, Ky.; Rochester, Minn.; San Jose, Calif.

DIGITAL TRANSDUCERS

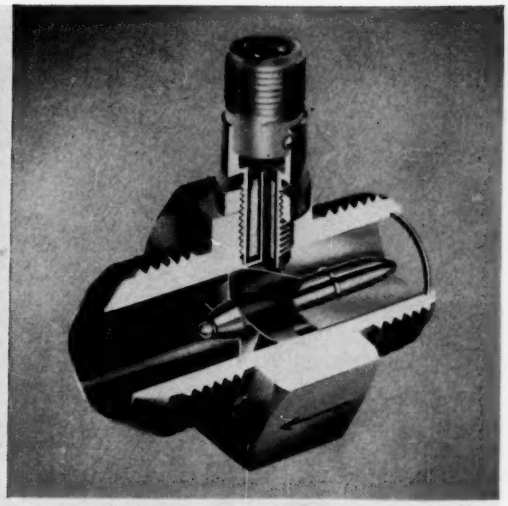

FIG. 21-1. TURBINE FLOWMETER is of time-digital type—that is, a digital output is available after given intervals of time.

DIGITAL AUTOMATION—NO. 21

Transducers are either true analog, true digital, analog-sensing with digital output, or time-digital. Rapid growth of digital techniques is increasing interest in transducers with digital outputs.

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Rocketdyne Div.,
North American Aviation, Inc.

WITH the advent of digital techniques the one component common to all systems has begun to receive increasing attention. This, of course, is the transducer. For many years manufacturers have furnished transducers of the analog type, safe in the knowledge that their product would be utilized in analog systems. Digital systems place the transducer in a new light because it is now the limiting factor in many control or data systems.

The application of transducers to the field of digital techniques is not much different from present practice in the analog field. The reason for this is the fact that the same transducer is used in most cases. With the introduction of digital systems it was only natural to start with the end product of the analog system—the data—and work back toward the beginning—the transducer. The concentrated effort that has been applied to the field in the past few years has resulted in great strides toward digitizing the information closer and closer to its source, the transducer itself.

In the near future more true digital transducers will become available. The sudden upsurge of digital systems has started a "new look" in transducers. Some true digital transducers are already available in the field; more will be developed in the future.

Types of Transducers

Transducers can be divided into four classes, as shown in Table 21-1.

Table 21-1. Types of Transducers

1. Class A—true analog type.
2. Class D—true digital type
3. Class AD—analog sensing element wth true digital output.
4. Class TD—time-digital type.

Class A—True Analog Transducers

True analog transducers are not only the greatest number available but are also the best known. Such transducers accept the parameter to be measured and produce an output proportional to it (usually a voltage).

Many analog transducers consist of two elements—an actuating element and a transducing element. Table 21-2 gives some of the commonly used actuating elements:

Table 21-2.—Actuating Elements

1. Bellows
2. Bourdon Tubes
3. Diaphragms
4. Vanes
5. Rotational Shaft motion
6. Rectilinear Shaft motion

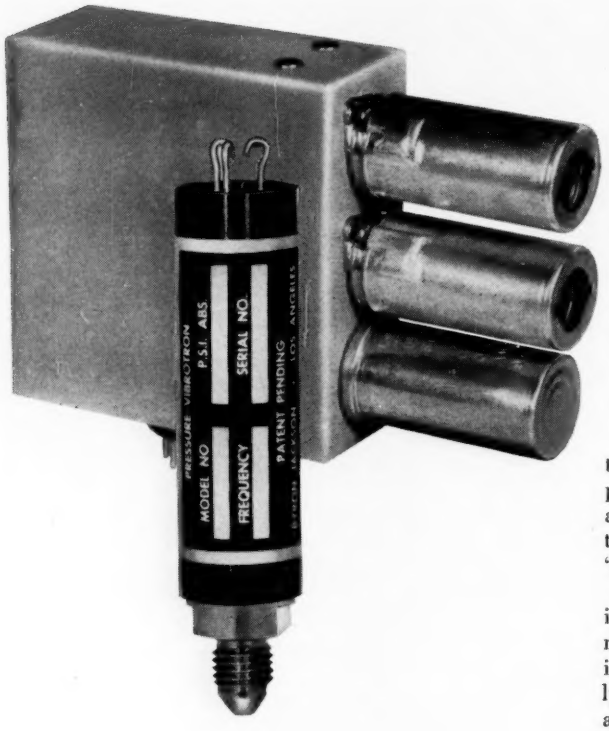


FIG. 21-2. VIBROTRON TRANSDUCER
is also of time-digital type.

These actuating elements are used to drive the transducing elements producing the output. Table 21-3 gives a few examples of these latter elements, all of which are of the voltage ouptut type which lend themselves to automatic control systems of the digital type.

Table 21-3.—Transducing Elements

1. Strain Wire
2. Potentiometer
3. Reluctance
4. Inductance
5. Capacitance
6. Optical
7. Magnetostrictive
8. Piezoelectric

Many analog transducers are of the direct type. Such transducers are represented by thermocouples, strain gages used to measure strain, resistance temperature bulbs, thermistors, etc. Most of these are devices with outputs in the low millivolt range. They can be used in digital systems by using analog-to-digital converters, as has been described previously. Many such transducers can be switched by mechanical or relay-type multiplexers without difficulty. For electronic commutation, however, an amplifier for each channel, ahead of the commutator, must be considered.

Class D—True Digital Transducers

A digital transducer furnishes information in digital form "on demand," without the intermediate steps of amplifying or encoding. Such a transducer accepts the varying parameter as its input and has as its output a series or set of characters which can exist only as discrete values. This output can be monitored continuously and can be obtainable either at all times or "on demand."

Probably the best example of this type instrument is the well-known *Shaft Position Encoder*, which is manufactured in many forms at present. Note that it is called an *encoder* rather than a *transducer*. Actually it is both. It is a digital shaft-position transducer, and its original use was in self-balancing potentiometers to encode the analog voltage into digital form. Although a shaft position was being read in digital code, the real intent was to digitalize the output of the analog transducer that was feeding the potentiometer—thus the name encoder was applied.

Class TD—The Time-Digital Transducer

This class of transducers can be considered as either analog or digital but in neither case is it direct. One example of this type of transducer is the turbine flowmeter (Fig. 21-1) and its associated magnetic pickup. The output of this device is a series of pulses, the frequency of which is poroportional to the rate of flow. The frequency is an analog of the flow, but to be of any use in an analog system it must be converted to a proportional voltage. Being a series of discrete pulses the output can be considered digital if time is allowed to enter. If the pulses are counted for a fixed interval of time the result is a digital number that can be used in a digital system. Note that this type of digital transducer does not produce digital information "on demand," but only after a specified period of time to allow for the counting.

Another example of this type of transducer is the Vibrotron, shown in Fig. 21-2.

Vibrotron operation is basically simple. A thin tungsten wire is cause to vibrate in a magnetic field; one end of the wire is fixed, the other is attached under tension to a pressure or force-sensing diaphragm. As the tension in the vibrating wire determines the output frequency, force changes on the sensitive diaphragm are transmitted in terms of frequency instantly and directly to associated indication equipment.

Much accessory equipment is available for use with such pickups.

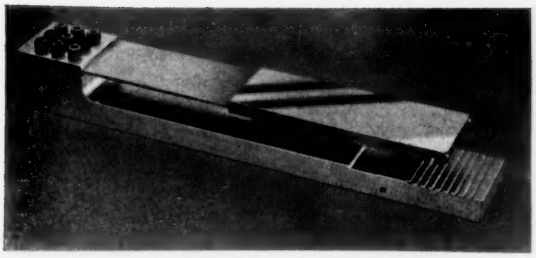


FIG. 1. IN THE FLEXURE sine bar the hinge of the normal sine bar is replaced by a flexure strip.

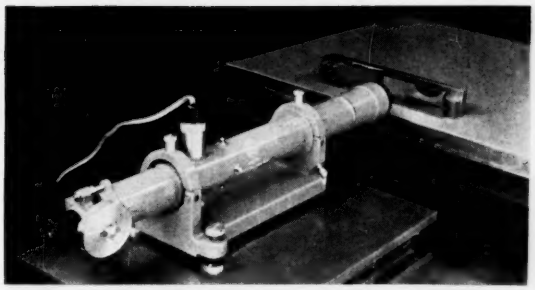


FIG. 2 MEASUREMENT OF θ is made by autocollimator. Deflection of tip is measured by gage blocks.

Flexure Sine Bar

AL CLINE
Northrop Aircraft, Inc.

TWO METHODS most commonly used for mechanical generation of precise angles at Northrop are (1) *sine bar and screw* and (2) *worm gear and worm*. Each has advantages and disadvantages.

One disadvantage of the sine bar is that the angle generated is not a linear function of the displacement of the end of the bar. Rather, it is a sinoidal function in accordance with the relationship:

$$\textit{Sine of output angle} = \frac{\textit{displacement of end of bar}}{\textit{length of bar}}$$

The approximation $\sin\theta = \theta$ becomes less accurate as θ increases from 0. If the accuracy of the approximation is satisfactory over the range of interest, then one of the major objections to the sine bar is eliminated. However, when seeking angular accuracy of the order of five seconds, the range over which the approximation $\sin\theta = \theta$ may be made is 0 to 3°. If the range of interest is 0 to 10° the sine bar becomes unsuitable for obtaining accuracies in the order of five seconds.

The purpose of this study and test was to extend the linear range of the sine bar by modifying it. Qualitatively, the modification investigated was based on the following observations:

(1) A true sine-bar generates decreasingly smaller angles as the input displacement increases (sine function).

(2) A cantilever beam produces increasingly greater end slope angles as the deflection increases (tangent function).

(3) The desired linear function lies between the sine and tangent curves.

(4) Therefore, by proper combination of the characteristics of (1) and (2) above, it was concluded that a closer approximation to the desired linear relationship could be obtained by their combination than either could supply alone.

A configuration embodying the two principles is contained in a sine bar with its arcs of rotation replaced with a flexure hinge of particular characteristics. Fig. 1 shows the modification of the sine bar in which the hinge of the normal sine bar is replaced by a flexure strip, leading to the name "flexure sine bar." An equation for error of this bar was derived.

The experimental flexure beam and setup is shown in Fig. 2. The beam was made of 4130 steel, heat treated to an ultimate strength of 190,000 psi. One side of the thick section was polished to a mirror polish. This permitted an autocollimator to be used to measure θ. The deflection s was measured with gage blocks accurate to 10^{-5} inch.

The experimental error was found to be approximately 7 times the theoretical error. This difference is attributed to two factors—(1) the assumptions involved in elementary beam theory upon which the analysis is based led to an error on the order of seconds, possibly minutes, and (2) the thick section of the beam actually bent an appreciable amount. Hence the assumption that the thick section is rigid is not satisfactory in terms of the accuracy desired. This means that the desired equation does not give a true or satisfactory description of the behavior of the flexure sine bar.

The effect of appreciable bending of the thick section is to make the flexure sine bar behave as a cantilever beam of variable cross-section.

Comparison of curves of error for both types of bar shows that the flexure sine bar is superior to the sine bar as a generator of linear angles. Thus, the basic idea of this modification of the sine bar is correct. The error could probably be further reduced by making the assumption of rigidity of the thick section better.

The test beam used is linear to approximately 30 seconds over the range 0 to 10 degrees.

ENI-, MENI-, MINI-, MONI-

-ACS

NELSON M. BLACHMAN
Electronic Defense Laboratory,
Mountain View, California

THE PRACTICE of giving automatic digital computers names ending in "-ac" began with the ENIAC, the first electronic digital computer, built at the Moore School of Electrical Engineering of the University of Pennsylvania during the war and put to work integrating ballistic equations at the Army's Aberdeen Proving Ground in 1947. The letters of the name ENIAC stand for the redundant combination "Electronic Numerical Integrator and Automatic Computer," the "-ac" having been agglutinated to the root "ENI."

Institute for Advanced Study Family of Computers

There seems to be a tendency to give different computers names with similar endings. Thus, the name "MANIAC" was proposed for several digital computers, but the Los Alamos Scientific Laboratory managed to preempt it for its own version of the Institute for Advanced Study computer. The latter had a prior claim but evidently relinquished it as too undignified. As a result, the Institute for Advanced Study computer has been left essentially nameless, while Los Alamos is starting its MANIAC II. The official etymology of "MANIAC" is "Mathematical Analyzer, Numerical Integrator and Calculator," but this is patently an afterthought.

Six other copies of the IAS computer have been built by four other groups. Of these, the most recent, located at the Weizmann Institute of Rehovoth, Israel, still lacks a name, but the others are interestingly named. There was once a tendency to call these computers generically "Johnniacs" after John von Neumann, who figured importantly in the design of the IAS computer, but that name now applies properly only to the copy built by the RAND Corporation. The version built by the Argonne National Laboratory is appropriately called "AVIDAC" (avid-ac) for Argonne's Version of the IAS Digital Automatic Computer.

Two copies of the IAS computer were built at the University of Illinois. Of these, the first, the ORDVAC (Ordnance Discrete Variable Automatic Computer), is at the Aberdeen Proving Ground working for the Ordnance Corps of the Army. The second, the ILLIAC (Illinois Automatic Computer), remains at the university. The ORDVAC might better have been called "ORDAC" for "Ordnance Digital Automatic Computer," but at the time its name was chosen the ending "-vac" was in style, as in EDVAC (Electronic Discrete Variable Automatic Computer), built at the Moore School for the Aberdeen Proving Ground, and UNIVAC (Universal Automatic Computer), built at the then Eckert-Mauchly Computer Corp. for the Bureau of the Census and other government agencies.

The remaining IAS-type computer represents something of an exception to the "-ac" rule of naming. It was built by the Argonne National Laboratory for the Oak Ridge National Laboratory and is called the ORACLE for "Oak Ridge Automatic Computer and Logical Engine." Another Oak Ridge digital computer, built for the inversion of matrices and the solution of simultaneous linear algebraic equations, had a prior and perhaps more reasonable claim to the name ORACLE. In its case, ORACLE would have stood for "Oak Ridge Automatic Computer for Linear Equations," but it lost this title to the newer and more powerful machine, and is now known simply as the "U.S. Air Force-Fairchild Specialized Digital Computer."

Harvard Computers

There are many other exceptions to the "-ac" rule of naming, as a matter of fact, starting with the Harvard Mark I, which commenced operation in 1944. This computer and its successors, Marks II, III, and IV, built at Harvard University by Prof. Howard Aiken, have been given the full names "Automatic Sequence-Controlled Calculator," "Aiken Relay Calculator," "Aiken Dahlgren Electronic Calculator," and "Harvard Magnetic-Drum Calculator," respectively. Of these, the first and fourth remain at Harvard; the second and third are now at the Naval Proving Ground, Dahlgren, Virginia. Harvard and IBM are almost alone in preferring "calculator" to "computer."

Renaming

Once a computer has been named, there is no assurance it will keep its name even though there are no competitors for it. For example, the first IBM large-scale electronic data-processing machine was conceived under the name "Defense Calculator," but this was later changed to EDPM 701, which, though less pronouncable, was more in keeping with the IBM numbering system.

From "*American Scientist*" Vol. 44, No. 2, April 1956

Another computer, the ERA 1103, built by Engineering Research Associates, recently got its name changed to "UNIVAC Scientific" in recognition of the fact that Remington Rand, which bought out the Eckert-Mauchly Computer Corp., builders of the UNIVAC, had also bought out Engineering Research Associates.

Winds

There is an assorted set of computers that were named for winds, though only one digital computer retains a windy name today, the Whirlwind at MIT. The Hurricane, built by the Raytheon Manufacturing Co. for the Naval Air Missile Test Center at Point Mugu, Calif., was renamed RAYDAC (Raytheon Digital Automatic Computer), while the Zephyr, built at the former Institute for Numerical Analysis of the National Bureau of Standards on the campus of the University of California at Los Angeles, was renamed SWAC (Standards Western Automatic Computer). The SWAC is expected to keep its present name although it has been transferred to the Office of Naval Research and its location is no longer a Bureau of Standards activity. The name Zephyr had been facetiously given to this computer because it was to be a more modest machine than the other winds.

Other computers named for winds are the Typhoon at the Naval Air Development Center, Johnsville, Pennsylvania, built by RCA, and the Cyclone computer at Project Cyclone, in New York, built and operated by the Reeves Instrument Co. However, these machines are analog rather than digital computers, except for the Typhoon's multiplier, which, in order to achieve the required accuracy, is digital. As a matter of fact, the names of analog computers are often not distinguishable from those of digital computers; a number of "-ACS" are analog devices, such as Reeve's REAC and Boeing's BEAC. (Other familiar analog-computer designations include the *GEDA* Goodyear Electronic Differential Analyzer, the *PACE* Precision Analog Computing Equipments of Electronic Associates, the *EASE* Electronic Analog Simulating Equipments of Berkeley-Beckman—Ed.)

SEAC Family

In Washington, in contradistinction to the SWAC, the National Bureau of Standards has the SEAC (Standards Eastern Automatic Computer), which was once known as the "NBS Interim Computer" because it was originally intended for use by the Air Comptroller pending delivery of a UNIVAC to the Pentagon. A number of other computers have been patterned after the now permanent SEAC. These include the FLAC (Florida Automatic Computer) at the Air Force Missile Test Center, Cocoa, Florida, the MIDAC (Michigan Digital Automatic Computer) at the Willow Run Research Center, Ypsilanti, Michigan, and the DYSEAC, built by the National Bureau of Standards for the Army Signal Corps in two large trailers for field use. Originally the DYSEAC had the name MOBILAC, connoting its mobility.

British Computers

In naming their computers the British have exhibited considerable ingenuity; the EDSAC (Electronic Delay Storage Automatic Computer) built at Cambridge University, which was the first stored-program digital computer in the world to be completed (1949), is the only one whose name ends in "-ac."

At the National Physical Laboratory there is the ACE Pilot Model (Automatic Computing Engine); the English Electric Company will produce a fully engineering version of the ACE, known as the DEUCE.

The Manchester Electronic Computer, whose prototype was built at Manchester University, and which is manufactured by Ferranti, Ltd., was the first British automatic digital computer to be produced commercially. It acquired the familiar name of MADAM (Manchester Automatic Digital Arithmetic Machine) late in life, falling in with the vogue of *doubles entendres*. Two copies of this computer have names of their own: the FERUT and the FINAC, whose names derive from their respective locations, the University of Toronto, Canada, and the Istituto Nazionale per le Applicazioni del Calcolo, in Rome.

French Computers

Two of the French Computers are particularly interesting on account of the word used for "computer," viz., the CUBA (Calculatrice Universelle Binaire de l' Armement) and the CAB 2022 (Calculateur Arithmétique Binaire), both built by the Société d' Electronique et d'Automatisme, Paris. Evidently, while in the U. S. "computer" and "computress" are both used to describe the operator of a desk calculator, in France these two terms both refer to a machine. It would be less confusing if "computer" were reserved for the machine and "computress" for the human.

Difficulty with sex also arises in the computer field in another connection. The adjective referring to the number base 16, as when binary digits are dealt with in groups of four, should be "sexdecimal" according to the usual Latin etymology for such words, but instead the hybrid "hexadecimal" is generally used.

Miscellaneous

This survey would be incomplete without reference to the NORC (Naval Ordnance Research Calculator), a unique computer which is regarded as the world's fastest, built by IBM for the Naval Proving Ground of the Bureau of Ordnance at Dahlgren, Virginia, and the LARC (Livermore Atomic Research Computer), which is being built by the newly amalgamated Sperry-Rand Corporation for the University of California Radiation Laboratory in Livermore, California. The LARC is expected to surpass the NORC by a factor of ten in both speed and memory size.

The Circle Computer, built by Hogan Laboratories, with the assistance of Nuclear Development Associates, New York, got its name from Columbus Circle, where it was originally conceived. Proving that anything ending in "-ac" goes, the General Electric Co., Schenectady, has named its computer OMIBAC without further explanation. Computers have come to be such individuals that the Argonne National Laboratory is going to call its forthcoming computer simply "George."

ELECTRONIC

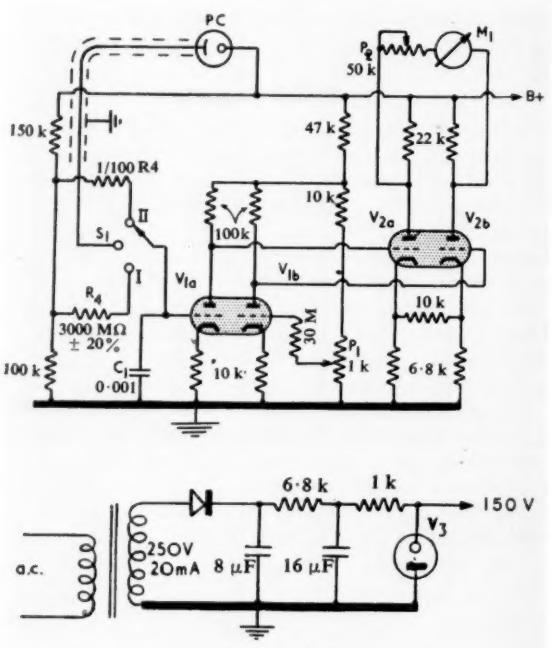
CHARLES F. KEZER
Digitronics Corp.
and
MILTON H. ARONSON
Instruments & Automation

LOGARITHMIC PHOTOCELL CIRCUIT

It often is desired to have a circuit that gives a reading proportional to the logarithm of a current or voltage, as in measurement of light intensity or transmission density. This circuit gives a reading proportional to the logarithm of the current output of a photocell.

Tube V1a is the logarithmic amplifier stage. It operates on the "retarded field" characteristic of the triode in which the grid is operated at a potential higher than the plate. The grid thus draws current and the input signal is a grid current. The plate current, and hence the plate voltage, is proportional to the logarithm of this input grid current under these conditions. V1 is a 12AU7 dual triode.

Positions I and II of switch S1 are for calibration; normal operation is in the center position. The photocell used (Cintel Type VA16 by Cinema-Television, Ltd.) supplies current linear with light intensity to within 5% in the range from 0.005 to 5 uamp.



Output of V1a and of the balancing triode section V1b is amplified in V2, also a 12AU7 dual triode. V1b provides zero setting and also heater voltage compensation. V2 must provide precisely linear current amplification because a small error subsequent to the logarithmic stage represents a considerable change in indicated light intensity; large degenerative cathode resistors (6800 ohms) are used to obtain this necessary linearity.

The indicator scale was graduated for a range of three decades in units of logarithmic transmission density D. The indicator has a 500-ua movement with zero offset so that pointer deflection corresponds to 125-0-375 ua. Graduation starts at 2.5D (—62.5 ua) and finishes at —0.5D (312.5 ua). Calibration points are at 2.0D (0 ua) and 0D (250 ua).

Capacitor C1 is of the plastic film type; it provides sufficiently long response time at the input grid to permit correct readings when working with a fluctuating light source. Potentiometers P1 and P2 are adjusted to calibrate the circuit; P1 corrects the zero of the logarithmic amplifier; P2 corrects the effective slope of its characteristic.

Input: 0.00632 ua to 6.32 ua at grid of logarithmic stage.

Output: —62.5 ua to 312.5 ua (see text).

Accuracy: Light intensities correct to better than 3%, readings repeatable to better than 1% of full scale.

Effect of line-voltage variations: 10% change alters readings by less than 1% of full scale.

B Supply: +150 v at 8 ma, VR-tube regulated as shown.

Source: V. H. Attree, University of Manchester, England; also *Journal of Scientific Instruments*, Feb. 1955.

TRANSISTORIZED GRAPHIC MILLIAMMETER WITHSTANDS 30-G SHOCK

This ruggedized recording circuit, designed for airborne use, works from the 28-v d-c and 115-v 400-cps aircraft supplies. The amplifier delivers 3 watts to a motor that moves a ball-point pen (in actual recorder, two circuits were used to drive 2 pens on one chart).

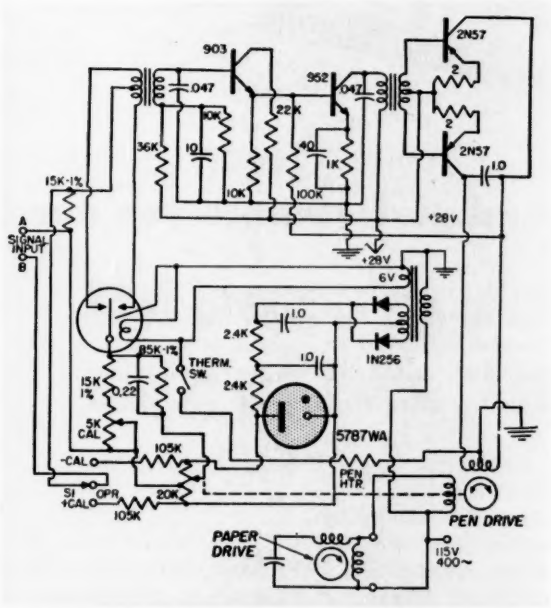
Input for full-scale is ± 0.5 ma dc. Error signal is converted by electro-mechanical chopper into a 400-cps signal and is amplified by 3 stages with over-all power gain of 66 db (factor of 4 x 10^6). Motor is 2-phase servo motor whose reference winding is energized from the 400-cps supply.

The transistors operate directly from the 28-v aircraft battery. The built-in 105-v regulated supply furnishes a calibration test current of ± 0.5 ma and also the balancing current that is applied across the 20K pot at lower left. The recorder is a null-balanced bridge in which the motor drives the wiper on the 20K pot to balance out the d-c input signal. Note that input B is applied to the center tap of the input transformer; input A is applied to the moving contact of the chopper in series with the followup voltage (portion of the 20K followup pot).

Negative feedback is provided from the collector of one of the output stages to the emitter of the input stage via a 100K resistor to stabilize gain from —55 to +70 degrees C. Further degeneration is provided by the 2-ohm resistors in the emitter circuit of the output stages.

CIRCUITRY

The circuit is the heart of all electronics. Here are 3 more basic and interesting circuits. Unless marked, resistors are in ohms, capacitors in microfarads.



The 1.0-uf capacitor connected across the motor terminals resonates the motor field winding, thus providing a resistive load for the transistors and greater power output (because a resonant circuit is effectively resistive).

The thermal switch is used to heat the ball-point pen to assure ink flow at low temperatures. Heating current is supplied from the 6-v a-c transformer winding.

Input: 0.5 ma dc full scale.

Input impedance: 15000 ohms.

Frequency response: Full scale to 3 cps; 1/10 scale to 15 cps.

Full-scale deflection: ± 2 inches.

Chart speed: 12, 3 or 3/4 inches per minute.

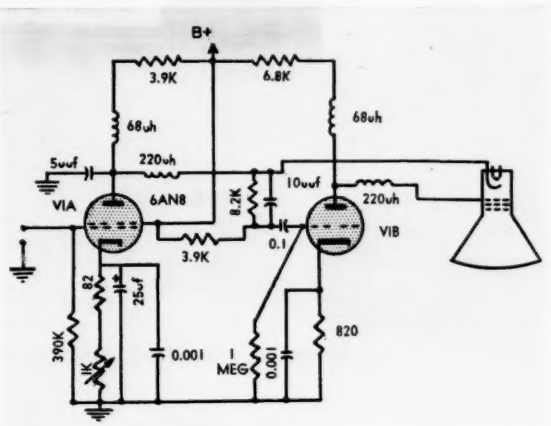
Power supply: 115-v rms 400-cps at 0.4 amp; 28-v d-c at 0.25 amp.

Source: G. Walters, Dalmo Victor Co., San Carlos, Calif.; also *Tele-Tech* & *Electronic Industries*, August, 1956.

PUSH-PULL VIDEO STAGE PROVIDES HIGHER OUTPUT

Smaller spot size and a brighter picture can be obtained in typical television receivers by increasing the picture-tube accelerating grid voltage to 450 v from the normal 300 v. To obtain proper contrast, the picture-tube grid voltage must be increased from the normal 60-v peak-to-peak to 100-v peak-to-peak. This cannot be done in many receivers which have available plate-supply voltage of only 120 v, using the conventional video amplifier stage. Such a stage might use a 12BY7A tube with plate load resistor of 5600 ohms, providing 60-v peak-to-peak output, with voltage gain of 28.

In the circuit shown, a phase-inverting amplifier drives both cathode and grid of the picture tube, in opposite phase. As the effective video signal is thus the sum of the two stage outputs, 105-v peak-to-peak video signal can be obtained, although the power-supply voltage is only 120 v.



The dual-section tube Type 6AN8 has a pentode and a triode section. The pentode section is driven from the video input. Input signal polarity is negative for blanking and positive for intensifying (sync negative). A part of the output of the pentode section output is taken off via the voltage divider consisting of the 8.2K and 3.9K resistors, and used to drive the triode section. As the signal voltage at the plate of the pentode section is out-of-phase with its input, the triode section is driven in phase opposition to the pentode section. V1A drives the picture tube cathode; V1B drives its grid. Thus a blanking (negative) signal at the grid of V1A drives the picture-tube cathode positive, tending to cutoff the electron beam, while the triode section completes the job by driving the picture-tube control grid negative.

The 68- and 220-uh inductors provide series and shunt peaking, as in the conventional video amplifier, to compensate the effects of tube and circuit capacitances at the higher frequencies. The IK contrast-control potentiometer in the cathode of V1A permits control of picture contrast by varying the gain of that stage.

Output at 5% distortion: Pentode section 50-v p-p; triode section 55-v p-p; total effective video signal 105-v p-p.

Bandwidth: Down 3 db at 3.4 Mc.

Voltage gain: 42

Power supply: B-plus current depends on contrast control setting: 120 v at 20 ma at maximum contrast.

Source: W. M. Clapp, Commercial Engineering Lab., CBS-Hytron, Danvers, Mass.; also *Electronic Equipment*, Dec. 1955.

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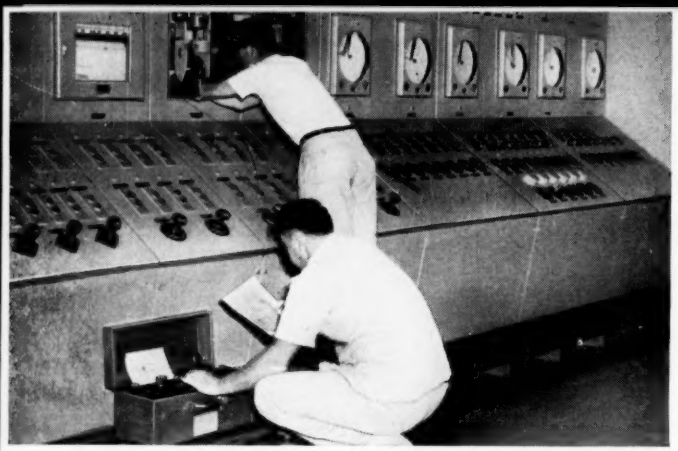

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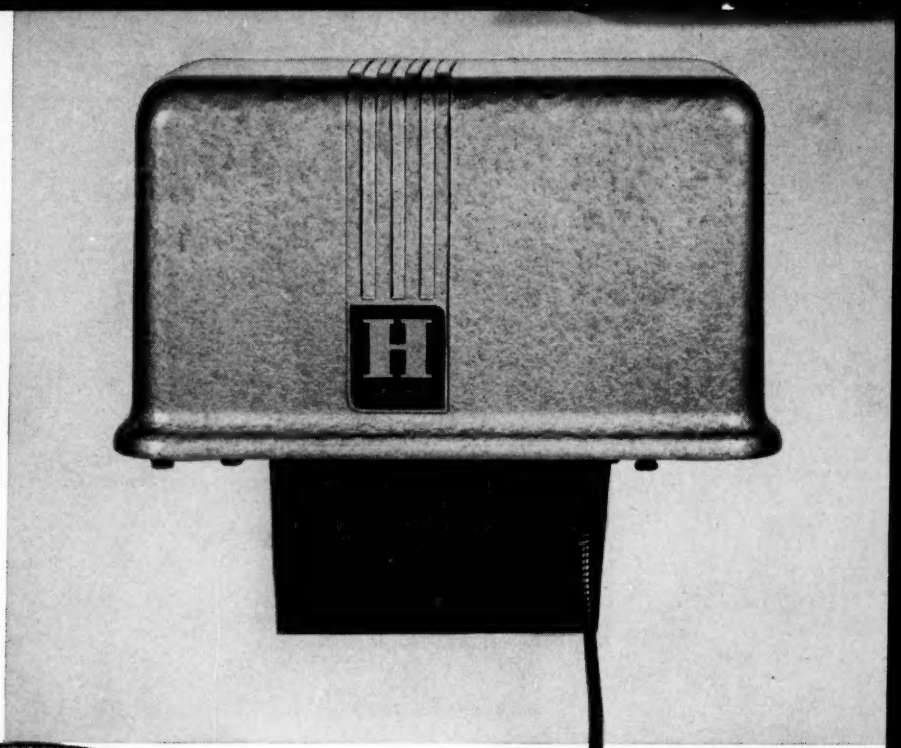
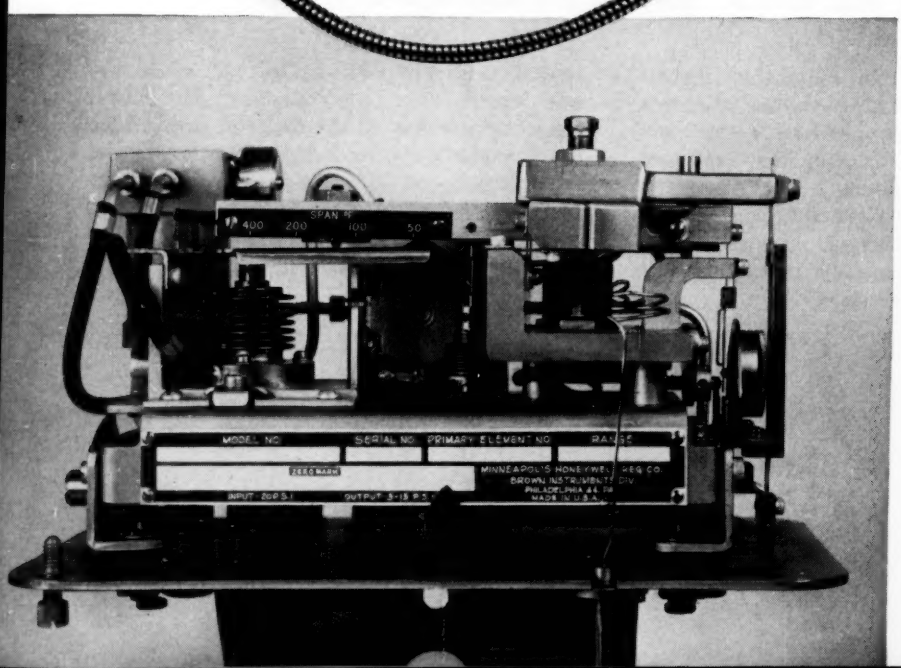
BROWN INSTRUMENTS

First in Controls

You can mount the transmitter at the point of measurement, either indoors or out. A sturdy, weather-proof aluminum cover protects all working parts and adjustments.





Interior view of the transmitter shows the accessibility of all parts. Span and zero adjustments are easy to make, and no changes of parts are required.

only the

TEL-O-SET transmitter–

gives you full rangeability

without changing parts

THE *Tel-O-Set* transmitter offers complete versatility. This highly accurate force-balance instrument measures temperature, gage pressure or absolute pressure, and transmits a proportionate output signal to a receiver or controller. It requires only one thermal system and one pressure system for all ranges, and changeover from temperature to pressure measurement is extremely simple.

You can adjust the span to any values between 20 and 150 psi, or 50 F and 400 F. And you can shift the span to cover any part of the overall transmitter range . . . from 40 to 600 psi, or from —375 to 1000 F . . . *without changing parts.*

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While offering the best in transmitter performance, the multi-purpose *Tel-O-Set* saves you the expense of stocking an assortment of thermal and pressure systems or spring assemblies . . . and simplifies the training of your operators and maintenance men.

Get complete details on *Tel-O-Set* transmitters . . . and related *Tel-O-Set* miniature indicators, recorders and controllers . . . from your nearby Honeywell sales engineer. Call him today . . . he's as near as your phone.

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BROWN INSTRUMENTS

First in Controls

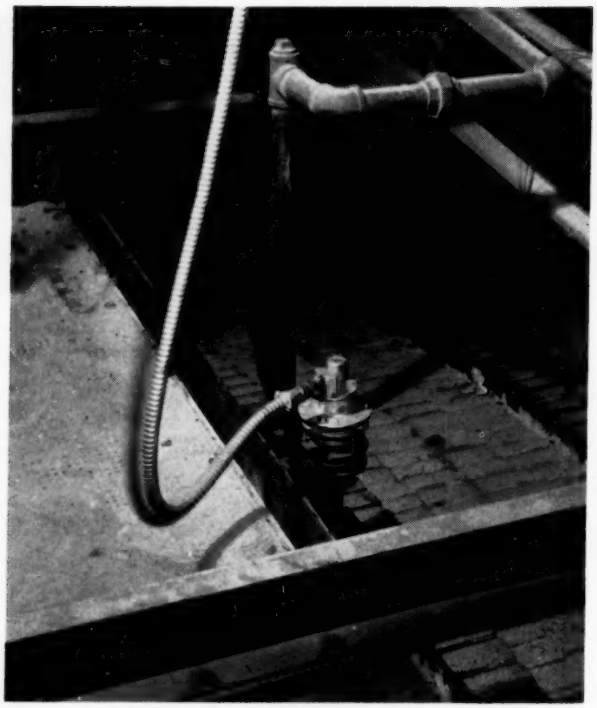


FIG. 1. ORIGINAL CENTER-ROOF installation. All succeeding installations have been patterned after this. Note that no water jacket is required.

"The open-hearth operators themselves are convinced that two-point roof-temperature control of open hearths is superior to single-point . . . we of the Fuel and Instrument Department are satisfied that this new technique has improved our ingot costs"

TWO-POINT ROOF

MEASUREMENT AND CONTROL of open-hearth roof temperatures at the Pittsburgh Works of Jones and Laughlin Steel Corp. has shown steady improvement since the time of the first installation in the older No. 2 Open Hearth Shop in 1938, even if progress has been slow at times.

From the time of the first installation of radiation units, the measurement and control of roof temperatures has been accomplished with the measuring device located approximately in the center of the open-hearth roof.

One cannot say that the installation of single-point recording-controlling equipment was not satisfactory from a performance standpoint, in view of the fact that the knowledge of the better performance available from the use of a two-point roof temperature control did not yet exist.

To give any one person or any one department full credit for the idea of using two-point roof temperature control would be a mistake. It was the result of ideas in several departments. One department is concerned with the erosion of sections of the roof and the number of roof replacements, another department is interested in the furnace outage time (with resultant loss of tonnage and rebuild costs) and a third department has been desirous of improving the instrumentation to the highest degree possible. The motive power behind all the thinking which resulted in multi-point recording-controlling was the curiosity of those men who wanted to know how high the temperatures were at the ends of the furnace roof where the greatest amount of erosion was occurring.

First System Used Three-Point Control

The first attempt to answer the question involved the installation of a three-point control on one furnace roof with primary elements located a few rings from each end towards the center, and one right in the center. The roof block which is sighted in each case is of the so-called "step" design. It has a disc cemented in place about 3″ above the hot face of the block. When this disc burns through in service, a slightly larger disc is dropped onto the ledge, provided for that purpose 3″ above the old disc. Still another ledge or "step" is provided 3″ above the last one. Thus, provisions are made for three steps, or a total of more that 9″ of refractory wear before the block is rendered useless. This has been found to be ample for a furnace campaign. No cooling equipment needs to be mounted on the block to protect the radiation measuring device

Presented at Sixth Annual Pittsburgh Conference on Instrumentation for the Iron & Steel Industry.

C. R. ELLSTROM
Jones & Laughlin Steel Corp.

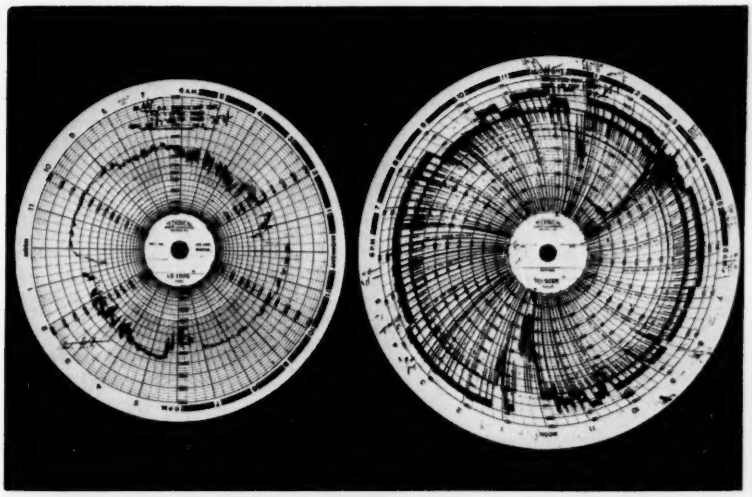


FIG. 2. CHARTS SHOWING two-point roof-temperature control at work.

TEMPERATURE CONTROL OF OPEN-HEARTH FURNACES

used, as the radiation unit on the installation will withstand ambient temperatures up to 350° F with no appreciable error in measurement.

Fig. 1 show a view of the original center-roof installation as described. All succeeding installations have been patterned after this one. It can be seen clearly that the only connection made to this unit is the electrical leadwire which runs to the recorder/controller in the control house. (Compare this with the unwieldly water-jacket-type installations needed previously!) The pipe shown behind the roof temperature pyrometer is the furnace-pressure impulse line.

Three single-point temperature recorders were used for this first installation, with the automatic fuel and air cut-back designed to function when the temperature at either end or at the center exceeded the maximum desired (3000° F). Results indicated that the center temperature seldom reached 3000° F (remaining around 2950° F), and that the controlled temperature was either measured on one end, or jumped from one end to the other—usually selecting the "outgoing-gases" end. This initial installation of three-point recording/controlling, while producing no phenomenal results during its trial period, indicated that the use of two-point roof temperature control would be a step in the right direction for greater roof life and resultant lower maintenance cost.

Two-Point Control

Fig. 2 is a good example of a two-point roof temperature control at work. The chart was taken from a two-point recorder/controller and its companion total-fuel/total-air recording instrument on a day when it was functioning properly. It must be understood that the operation of the roof temperature controller does not in any way take away any of the responsibility for furnace efficiency and refractory life from the furnace operators. Although the controller is at present set to control at 2990° F, at times the first helper of a furnace will disregard this limit and bypass the fuel control valve in order to put more fuel on than called for, and thereby will raise the temperature of the roof to 3020-3080° F, or higher.

In an attempt to curb the heights of these over-temperature peaks, a temporary agreement with the Open Hearth supervision was reached: When the operator of the furnace felt that his furnace was not hot enough, he was allowed (after obtaining the Melter's O.K.) to ask the combustion man on the floor to raise the maximum roof temperature control point to 3010 or 3020° F, for the period needed to obtain the desired results, and then have it lowered to the original control point of 2990° F. Later it was decided that raising the control point to 3020° F would bring the temperature of the center of roof closer to 2990° F.

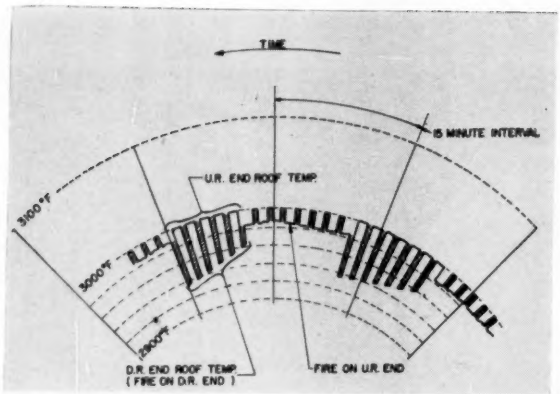


FIG. 3. ENLARGED SECTION of chart of Fig. 2.

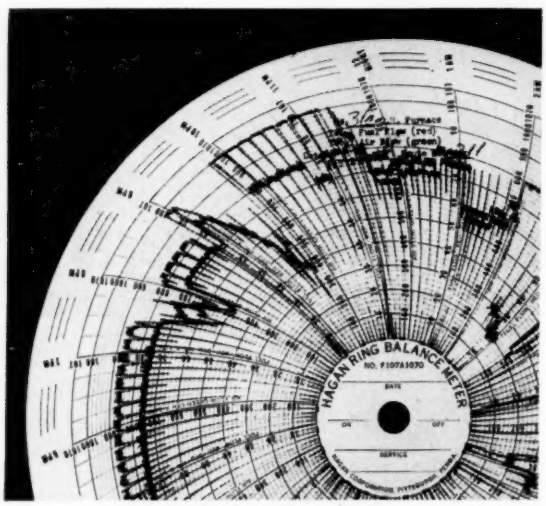


FIG. 4. PORTION OF CHART with center-roof control.

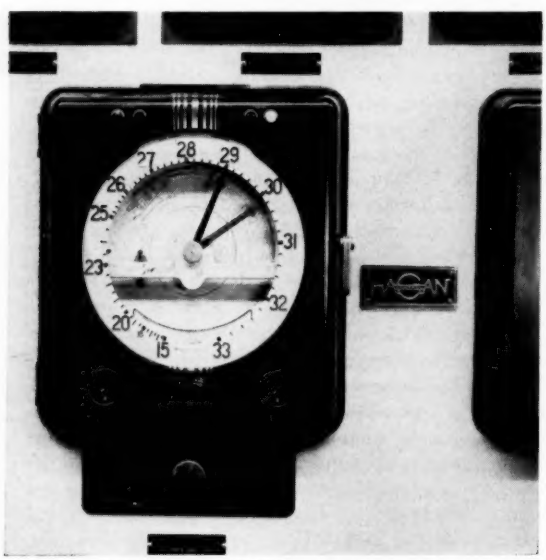


FIG. 5. ONE OF THE TWO-POINT roof-temperature controllers.

Analysis of Chart Record

For the purpose of explaining the recording on a two-point roof temperature chart, a section has been enlarged in Fig. 3. The ends of the furnace are designated as up-river (U.R.) and down-river (D.R.) ends. Temperature recordings on the up-river end are made every forty seconds; temperatures on the down-river end are recorded every eighty seconds. These intervals were selected to give clarity to the recording, and to give maximum protection to the furnace roof by not recording on either end for too long a period.

Analysis of this record is revealing: In charts made with center-roof control alone (Fig. 4), the chart pattern with the narrower spacing appears as an unbroken line (due to the width of the pen marking) and, therefore, is easily identified. In Fig. 3 the fuel was incoming on the down-river end and the out-going gases were at control temperature during this period. Temperature at the incoming end averaged 50 F° less, with a gradual temperature drop from 2980 to 2940° F in a period of approximately 12 minutes. This drop may have been influenced by the drop in preheat-air temperature toward the end of the reversal period. However, after reversal, when the fire was placed on the up-river end, the temperature difference between the incoming and outgoing ends was within 20 F° of the control temperature. Several factors other than preheat-air temperature could account for this difference, such as a thinner roof section and air infiltration through the furnace body, flow pattern of incoming air, position of burner, etc. (We have found that the temperature pattern is seldom similar when firing from one end as compared to the opposite firing direction.) While this temperature difference is not too great at high temperatures, it shows that a temperature difference of as much as 60 F° (and perhaps greater) can exist along the furnace roof. Controlling from one point near the roof center, therefore, will not necessarily protect against exceeding the safe temperatures for silica roof brick.

Fig. 5 is a picture of one of the two-point roof temperature recorder-controllers. In the initial installation a complete instrument was purchased which took considerable time for delivery. In succeeding installations only the necessary parts were ordered to convert the single-point roof temperature recorder-controllers to two-point instruments, and the conversions were made in our own shop. Approximately 32 to 40 hours were needed for each conversion.

At the top of the instrument two sets of lights can be seen having a red and a green light each. The two lights on the left show which end of the furnace is recording, and the lights on the right designate the end from which control is exercised. It is possible that one of the control lights remains lighted for several hours because of furnace temperature conditions. Although the temperature recording is switching from one end to the other, the "memory circuit" within the instrument retains the knowledge of whichever end is hotter. These lights and the instrument's temperature index afford the furnace operator the possibility of knowing instantly the temperature at each end of the furnace. They also enable the combustion man on duty

(who has the responsibility of checking the accuracy of the instrument) to compare more quickly the results of his optical checks (obtained with portable instruments) with those shown on the recorder. If, for any reason, one of the Rayotubes should become inoperative, the recorder-controller can be set to operate from the other unit. In some rare cases it was possible for a furnace to end a campaign with the roof controls out of operation for the last few heats (especially when the number of heats of a campaign was as high as 152).

Results

Where something new is tried it is appropriate to ask what benefits have been derived, or what the possible savings are. There are some monetary or operative savings that are of an intangible nature. Table 1 shows some results that can be attributed to the installation of the two-point roof temperature control on No. 4 Open Hearth.

In the column on the right there are two different heat-size designations—250 tons and 275 tons per heat between April and June of 1954. In view of this, it was necessary to separate the data for comparisons on an equivalent basis for the separate categories of 250 and 275-ton heats because of the extended period of time covered by the installation of the two-point roof temperature equipment. With the elimination of one possible variable the rest of the data is possibly more readily understandable—with two exceptions: In the number of heats per unit roof, No. 45 Furnace and No. 50 Furnace show worse results; in these cases it is interesting to note that No. 45 Furnace data are given for 275-ton rated heats and No. 50 Furnace data are for 250-ton rated heats. Looking further into the available information for these two furnaces we find that despite the backward help of these two furnaces, the shop averages for the two different size heats shows up in an appreciable amount. We believe that it is reasonable that there should be a greater difference in the results accrued on the 250-ton heats, as it is possible that there would be less drive or push on a furnace making the smaller-size heats.

Table 1—Comparison of Roof Life Performance

Single-Point Roof Temperature Control vs Two-Point

Fce No.	Single-Point Control	Two-Point Control	Rated Heat Size
41	91.1	—	275 tons
42	84.8	88.2	275 "
43	84.6	91.4	250 "
44	92.2	97.9	275 "
45	97.3	86.8	275 "
46	72.4	103.2	250 "
47	97.6	108.7	275 "
48	72.4	90.6	275 "
49	109.4	138.1	275 "
50	95.0	85.2	250 "
51	Not used—Changed to two-point control at time of heat size change.		
Shop Average (Excl. #41)	93.4	95.2	275 tons
Shop Average	79.1	89.4	250 "

In conclusion, relative to the performance of single as compared with dual-temperature control, while there are always many other variables at work which are influencing the performance of the furnaces, the tabulation indicates that seven out of the nine studied furnaces improved in roof life performance. We believe the results to be sufficiently conclusive to warrant the usefulness of two-point roof temperature control.

This improvement, evaluated in dollars, appreciably offsets the installation and maintenance costs of the instruments.

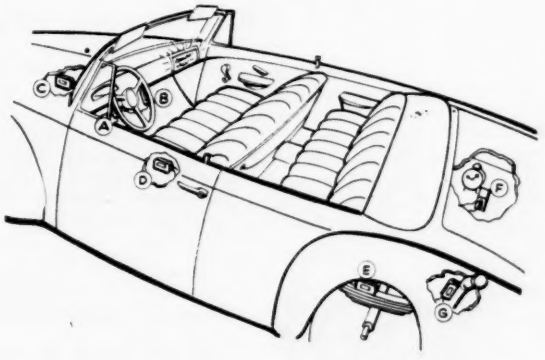
The open-hearth operators themselves are convinced that two-point roof-temperature control is superior to single-point control. Therefore, we of the Fuel and Instrument Department are satisfied that this new technique has improved our ingot costs.

How To "Teen-Age Proof" Your Car With Switches

SWITCHES A, B, C, D, and E are wired in series with the car's ignition system. Switches "A" and "B" are so mounted that if either hand is removed from the steering wheel, the motor quits. If the speedometer needle passes 50 M.P.H. it actuates switch "C" which also stops the car. Switch "D" cuts the ignition when more than one person is on the driver's side of front seat. Should more than six passengers attempt to crowd into the car, switch "E," which is actuated by the added weight on rear springs, prevents starting the motor.

Switch "F" is actuated by an alarm clock (preset and locked in luggage compartment by the parents) which, at curfew time, lights a sign on the dash reading "It's late, go home!"

Explosion-proof switch "G" beneath gas tank cover is wired to the horn. On nights when son is denied use of the family bus, this switch warns father when son tries to syphon gas into his buddy's hot rod.



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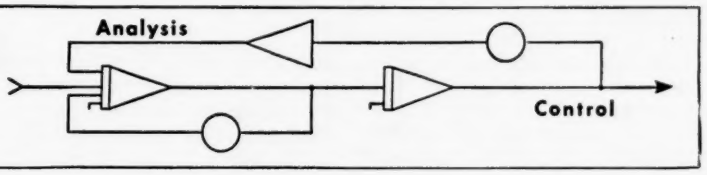
The SIMULATION COUNCIL Newsletter



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Bits

This issue of the *Newsletter* might well be called the *Hideo* Mori* (Dynamic Analysis and Control Lab., MIT, Cambridge, Mass.) number because we are indebted to him for the minutes of the January and March meetings of the Eastern Simulation Council, which constitute Pieces in this month's Newsletter. Discussion at these meetings centered around resolvers and the simulation of nuclear reactors.

Information Without Theory is also indebted to Hideo's notes, since it is concerned with discussions of the Eastern Simulation Council's study groups.

Pieces

EASTERN S/C MEETING OF 28 JANUARY ON "RESOLVERS"

About 75 people representing 40 different groups attended the thirteenth Eastern Simulation Council meeting at the Applied Physics Laboratory of Johns Hopkins University (Silver Spring, Maryland) on 28 January 1957. Their subject was "Resolvers."

Dr. James Follin (JHU/APL) welcomed those attending the meeting and recalled that the organizational meeting of the Eastern Simulation Council was held at Johns Hopkins two years ago.

*The fact that it was written by Hideo and changed by us does by no means justify anyone's saying that the writeup is Hideous!

Loveman on Definitions and Evaluations

Bernie Loveman (Reeves Instrument Corp., New York, N. Y.) began the technical discussion. His presentation* was divided into three parts: definitions and evaluation of resolver performance; a description of some new resolvers that Reeves is building; remarks concerning electronic resolvers.

Bernie described a resolver as a black box capable of operating in either of two modes: polar or rectangular. In the former the value of the two components of a vector are the inputs, e.g., $y = A \sin \theta$ and $x = A \cos \theta$, and the outputs are the vector A and the angle θ. When operating in the rectangular mode there may be three inputs A, B, and θ and two outputs, usually $A \cos \theta + B \sin \theta$ and $-A \sin \theta + B \cos \theta$.

*Like Gaul

Bernie said the factors required to evaluate performance of resolvers are static accuracy, dynamic accuracy, noise, and life.

Three factors determine the static accuracy of servo resolvers: resolver conformity, linearity of the followup potentiometer, and gear ratio between followup and resolver. When giving percent error, the manufacturer should specify whether the error is divided by the peak-to-peak voltage or the zero-to-peak voltage. Spot checks on a resolver do not give a good indication of its quality. The output of a sine-cosine potentiometer should be recorded on a plotting board to reveal any errors in conformity which might not be found by point checks. An alternative procedure would be to compare $A \sin \theta$ with $B \sin \theta$ with $A = B = 100$ volts.

The error in positioning the follow-

up potentiometer with respect to the resolver can be much greater than the conformity error. With + 100 and —100 volts across the followup potentiometer, this error in percent is given by

$$E = (200/57.3)(\lambda g)$$

where λ is the followup potentiometer linearity in percent, and g is the gear ratio in degrees per volt. For example, with an 0.025% potentiometer and 2° per volt gear ratio, the position error at the resolver will be 0.17%. On the other hand, if the gear ratio were increased to, say, 20° per volt, then the error would be 1.7%.

The dynamic accuracy of a resolver servo is usually given by amplitude and phase curves. From the user's point of view, a better method would be to present error data as a function of frequency, Bernie said.

Specifications on noise should include both the rms value and data on the peak-to-peak noise.

Finally, the life of the resolver was defined as the period of time for which it remains within specifications, not the total time before you throw it away. Experience at Project Cyclone indicates that the average life of sine-cosine potentiometers, with a maximum velocity of 30 rpm, is one year, after which the sine-cosine cards must be removed and cleaned.

Because life, accuracy, and resolution (there is no granularity) are much better for induction resolvers than for sine-cosine potentiometers, Reeves developed an induction resolver system for use in the Wright Air Development Center computing facility. The schematic diagram Fig. 1 indicates how Reeves has handled the problem of accurate modulation and demodulation. The input modulators produce square waves proportional to the inputs. A peak-to-peak phase-sensitive detector is used in the output, and a special center-band chopper circuit samples the center of the square waves. The purpose of feedback networks in the detection circuit is to smooth the output and improve the dynamic accuracy.

Using a 400-cycle square-wave carrier, Bernie quotes the static error (including modulator, demodulator, and resolver) as 0.08% of the zero to peak voltage. The dynamic error, with respect to either A or B input, is about 0.5% at 10 cycles.

Bernie then turned to the controversial topic of *electronic resolvers*. As one of the key elements of an electronic resolver is an electronic multiplier, usually of the time-division type, and as Bernie expressed the opinion that dynamic accuracy of today's time-division multipliers is not even one order of magnitude better than the accuracy of a high-quality servo* he feels that the performance of electronic resolvers leaves something to be desired.

In answer to a question about the design of special filters, Bernie agreed that phase shift could be reduced, as in the RCA multiplier (see *RCA Review* December 1955, pp. 618-633), but only at the expense of an amplitude rise of 8 to 10 db at some higher frequencies. This may be permissible for special-purpose computers, but for general use in solving a set of simultaneous differential equations there will be closed loops in which these multipliers will produce oscillations.

Merritt on Varying Loop Gain

Nelson Merritt (Mid-Century Instrumatic Corp., New York, N. Y.) brought out the problem of varying loop gain when a servo resolver is used in the polar mode. If we consider a servo which uses the $-x \sin \theta + y \cos \theta$ output of a resolver as an error signal, then the servo will

*For details of Bernie's opinion of electronic time-division multipliers, see last month's *Newsletter*.

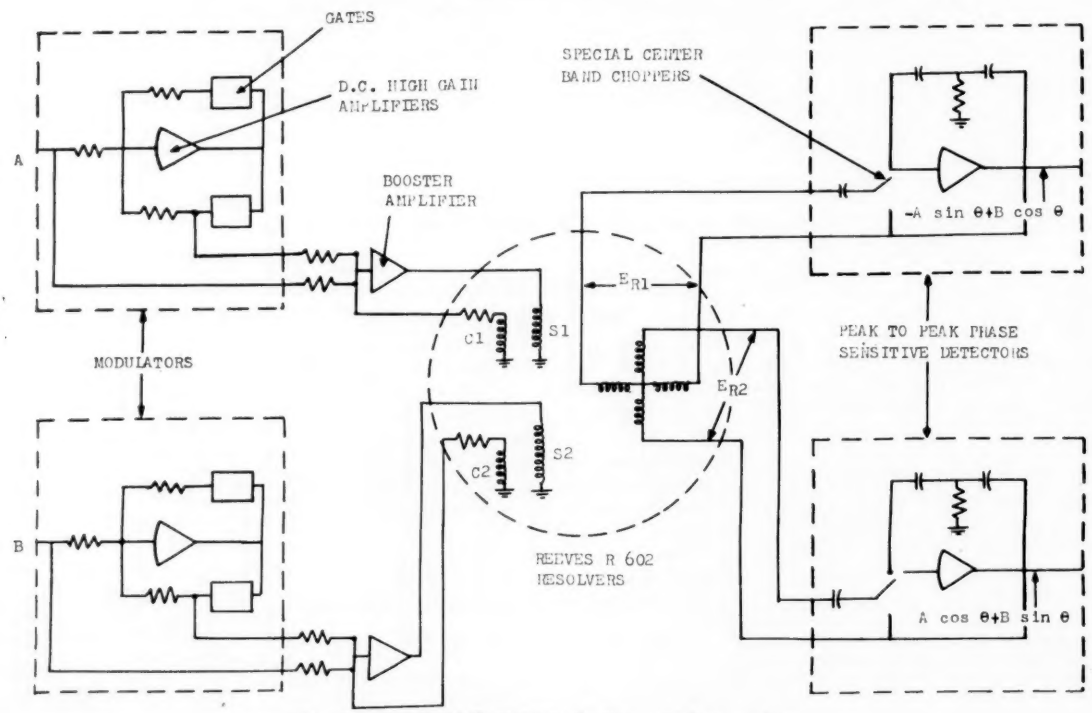


Fig. 1. The "REAC 400" induction resolver system.

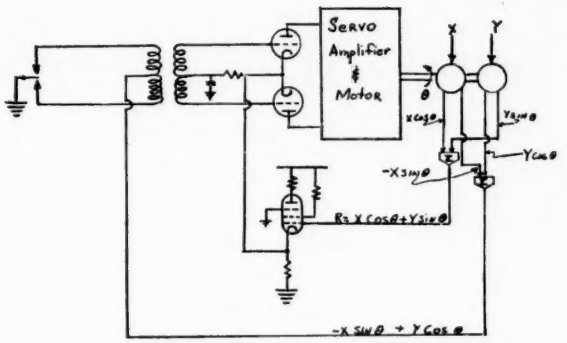


Fig. 2. Automatic gain control of resolver.

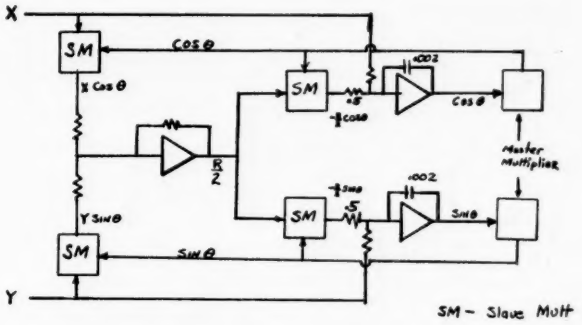


Fig. 3. Electronic resolver.

position the shaft θ so that $\theta = \tan^{-1} y/x$. If other factors are constant, such a servo becomes unstable for large values of xy or insensitive for small ones. Fortunately the other output of the resolver, x cos θ + y sin θ, can be used to control the loop gain to counteract the effect of this variation. Merritt's scheme for automatic gain control is shown in Fig. 2. The dc voltage corresponding to x cos θ + y sin θ is applied to the grid of a sharp cutoff pentode, which in turn changes the cathode bias of a push-pull stage of the servo amplifier, which is used to drive the θ input of the resolver.

Weyrick on Vector Resolution at Goodyear

The next speaker, *R. C. Weyrick* (Goodyear Aircraft Corp., Akron, Ohio), described recent developments at Goodyear for use in vector resolution: their dc servo, their electronic resolver, and a quadrant switch used to extend the usefulness of their servo resolver.

The Goodyear A14 computer has transistorized dc servos which contain sine-cosine potentiometers. These have a 3-db peak at 46 cps and are down 3 db at 76 cps with a 2-volt peak-peak input. The acceleration limit is in excess of 100,000 volts/sec^2 and velocity limit is 5500 volts/sec. A stabilized dc amplifier is used for most of the loop gain, and there is an output stage with 4 transistors in a symmetrical circuit, two transistors for positive signals and two negative. Automatic gain control is also available so that the resolver can be used in the polar mode.

The Goodyear electronic resolver is a precision diode function-generator which uses a dither voltage to round out the break points. Five silicon diodes serve to approximate the trigonometric function which yields a static error of 0.2% of full scale. There is a 2° phase shift at 100 cps and a 3° shift at 300 cps.

Bernie Loveman pointed out that multipliers are necessary if a rectangular mode of operation is required from this electronic resolver.

The quadrant switch consists of electronic integrators, precision-amplitude comparators, and switching circuits. One of its functions is to extend the angular range of the resolver to a full ± 180°, not normally possible because of limits in feedback potentiometers.

Static accuracy of 0.25% and dynamic accuracy of 1% at 180° per second can be expected using this switch. The switching circuits not only reverse the servo when 180° is reached, but also switch polarities of the cosine function so that it appears to be continuous. The largest inaccuracy occurs when this takes place.

Carbon-film pots are used in both linear and sine-cosine potentiometers. Also available is a mode of operation which allows use of a rate input to the servo.

Wadlin on Electronic Resolver

Milo Wadlin (Radio Corporation of America) next described the electronic resolver shown in Fig. 3. Because of their experience at Typhoon, RCA decided to build an all-electronic computer. The electronic resolver uses the x and y inputs to give cos θ and sin θ, where θ is tan $^{-1}$y/x. The unit requires two master multipliers and four slave multipliers. The amplifier with the 0.002-mfd feedback capacitor is not an integrator but a high-gain amplifier with only sufficient capacitive feedback to keep the circuit stable.

MEETING OF EASTERN S/C OF 22 MARCH ON "SIMULATION OF NUCLEAR REACTORS"

The fourteenth Eastern Simulation Council meeting took place at the American Machine and Foundry plant in Greenwich, Connecticut, on March 22nd and was attended by about 65 persons representing 31 groups. Subject of the meeting was "Simulation of Nuclear-Reactor Systems."

McPhee on AMF Reactor Simulator

Al Gronner welcomed the group and introduced *John McPhee* (AMF) who described an attachment built by American Machine and Foundry for their general-purpose analog computer to simulate kinetic behavior of the reactor itself, or the fission process. The equations simulated are

$$\frac{1}{\alpha}\frac{dN}{dt} = (1-\Sigma\beta_i)K_{eff}N - N + \sum_{i=1}^{6}\frac{C_i}{\tau_i} + S$$

$$\frac{dC_i}{dt} = \beta_i K_{eff} N - \frac{C_i}{\tau_i}$$

There are seven simultaneous differential equations, and the method of simulation has been worked out so that only two basic computing amplifiers are necessary. Fig. 4 is a block diagram of the equations, and Fig. 5 is a functional diagram of the AMF reactor simulator showing how the equations can be solved using only two amplifiers. The delayed neutron feedback groups $\Sigma\beta_i$ can be simulated by RC networks because the gains β are small, ranging from 0.0025 to 0.00025. The variable N is neutron power or neutron concentration, the variable S is the source, N can be greater than S by as much as 10^{10}. The source S is not the input to the system; the system is parametrically forced and the vari-

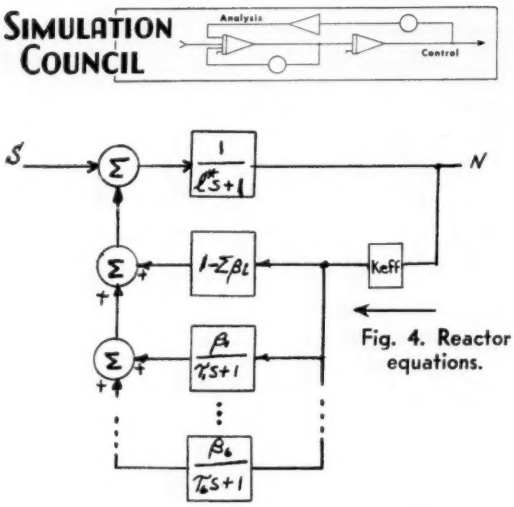


Fig. 4. Reactor equations.

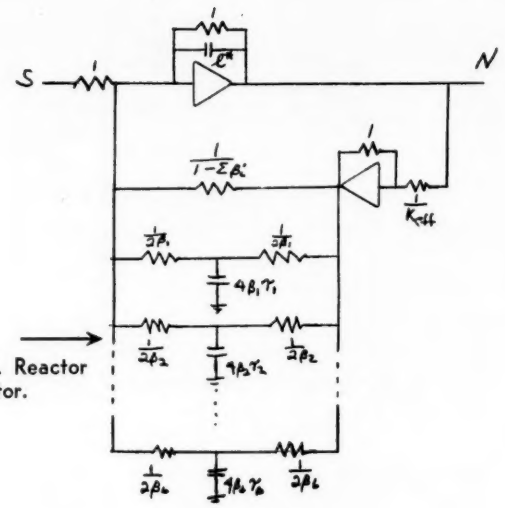


Fig. 5. Reactor simulator.

able K_{eff} can be considered as the input.

A nuclear-reactor system is a closed-loop positive-feedback system with a loop gain close to one, so that to increase the power level N one has only to make K_{eff} greater than 1 for a short period of time. K_{eff} is the multiplication factor of the reactor and is a measure of the number of neutrons born in a finite time. K_{eff} is the ratio of the number of neutrons born to the number of neutrons absorbed in fission, plus those lost in other absorbing processes, plus those that leak out of the pile. If K_{eff} is greater than 1 the reactor is in a supercritical condition, while if K_{eff} is less than 1 it is subcritical.

There are potentiometers whereby each value of β_1 can be adjusted. Capacitors are not adjustable because for all practical purposes the decay time constants for different fuels are the same. There are provisions for initial conditions and also for simulating some problems of circulating-fuel reactors. The capacitor for l* is a plug-in unit so that it can be changed for various reactors. The simulator does not have any provisions for taking care of dead time, which prevents it from simulating certain types of circulating-fuel reactors.

Mariani on L&N Reactor Simulator

Following John's talk *Mr. C. Mariani, Jr.* (Leeds & Northrup Co., Philadelphia, Penna.) discussed a nuclear-reactor simulator for educational use. Although the best all-around facility for laboratory instruction might be a critical reactor assembly, the high initial cost and subsequent operating expenses, and the tendency for critical reactors to be monopolized by research projects sometimes make this impractical. Besides, any useful assemblage of fissionable material capable of going critical, even at low power levels, constitutes a hazard in the hands of inexperienced student experimenters.*

The reactor simulator described by Mr. Mariani is to be used for the study of reactor kinetics, evaluation of reactor control systems, and for reactor operator training. The L&N simulator provides a vivid graphic demonstration of reactor kinetics, as well as demonstrating the nature of discontinuous servo control as applied to nuclear reactors. It also makes visual training in reactor operation both dramatic and effective.

The simulator assembly consists of an instrument panel, control console, and a reactor core mockup (nonradioactive**) equipped with two safety rods operated from one drive unit, and one control rod with its own drive unit.

On the instrument panel are:

1. A Log N recorder, calibrated 0.0001 to 300% power
2. A period recorder, minus 30 to infinity to plus 30 seconds
3. A linear power level recorder, zero to 150% power
4. A log count rate recorder, zero to 10,000 cps
5. PAT*** servo unit—discontinuous relay output, with proportional, reset, and rate functions
6. Analog computer

On the operating console are various auxiliaries: switches, indicators, and signal lights. These allow the student to operate the simulated plant like an actual reactor.

On the console are:

1. The safety rod raise-lower switch and position indicator
2. The control rod raise-lower switch and position indicator
3. The safety and control rod position signal lights
4. The scram button*
5. A receptacle for remote instructor operation of the control rod.

A computer similar to that described by McPhee is used in the simulator. The simulator has been designed with flexibility in mind:

1. By changing the value of the plug-in feedback capacitor, a variety of thermal reactors can be simulated.
2. Various fuels can be simulated by changing the potentiometer setting, which varies the fraction of each of the delayed neutron groups. The contribution of each of these groups can be eliminated with a switch.
3. Control and safety rod worths can be changed with plug-in resistors. ΔK of the control rod is variable from ½% to 10%, while each safety rod can be varied between ¼% and 5%.
4. Various step-function changes in reactivity in both positive and negative directions can be introduced by operating switches on the computer panel. Plug-in resistors allow the magnitude of changes to be varied between ¼% and 7% of control rod worth.

The simulator can be operated in both open- and closed-loop condition.

1. *Open Loop*—Reactor kinetics can be studied by inserting step-function changes in reactivity of various amounts and observing period and neutron level response. This can be extended for different safety- and

*!

**Oh!

***?

*Handiest gadget we've heard of yet. Is there a portable model for home and office?

control-rod worths, and further expanded for different mean life times. Ramp function changes also can be introduced by withdrawing the safety or control rods. By changing rod worth, various rates of ramp reactivity changes can be made. Dynamic reactor behavior can be observed by noting period and neutron level response, which can be read directly from the recorders. Other parameters can be changed to increase the range of experiments performed.

2. *Closed Loop*—In this mode responses of the control system can be studied easily.

Barnes on Power-Plant Simulation

John Barnes (General Electric Knolls Atomic Power Laboratory) spoke on the simulation of a liquid-cooled reactor power plant, and explained some fundamental principles of water-moderated reactors. As shown in Fig. 6, the reactor is the source of heat for the primary water which is circulated through a heat exchanger. Heat from the primary loop is thus passed to the secondary loop, where steam is made. The steam goes through a throttle valve into a turbine, and condensed steam from the turbine is pumped back into the boiler.

John described the simulation of each of the blocks shown in Fig. 7. The reactor is a one-delay group approximated by a 10-second time constant. The RC combination around the high-gain amplifier is such that if a positive potential is on the grid, the output N goes negative, and if a negative potential is on the grid the output goes positive. If the grid is zero, the output will be constant. ΔK is the reactivity which is considered to be the driving function for the reactor. The source need not be considered since we may assume that the reactor has been started. Reactivity is changed by adjusting the control rod. This reactor model is good for $\Delta K = \$1.00$, plus or minus perhaps 30 cents.

Called upon to explain the business of dollars and cents*, John said to assume that the delayed group $\Sigma\ \beta_i$ is equal to about 0.0073, i.e. approximately 0.7 of 1 percent of all of the neutrons are coming from delayed emitters. This indicates the influence of the delayed neutrons as compared with the prompt ones. If K is the multiplication factor of the assembly, i.e., on the average, the number of neutrons being made in one generation as compared with the past generation, then δK can be normalized by dividing by β_i to give ΔK. Now if ΔK is made equal to 1, the reactor will be critical on prompt neutrons alone. So prompt critical is plus $1.00.

*Is he married?

Fig. 6. Power reactor.

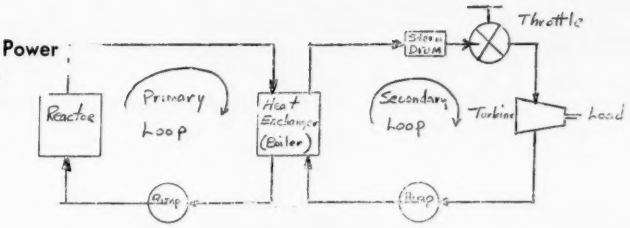
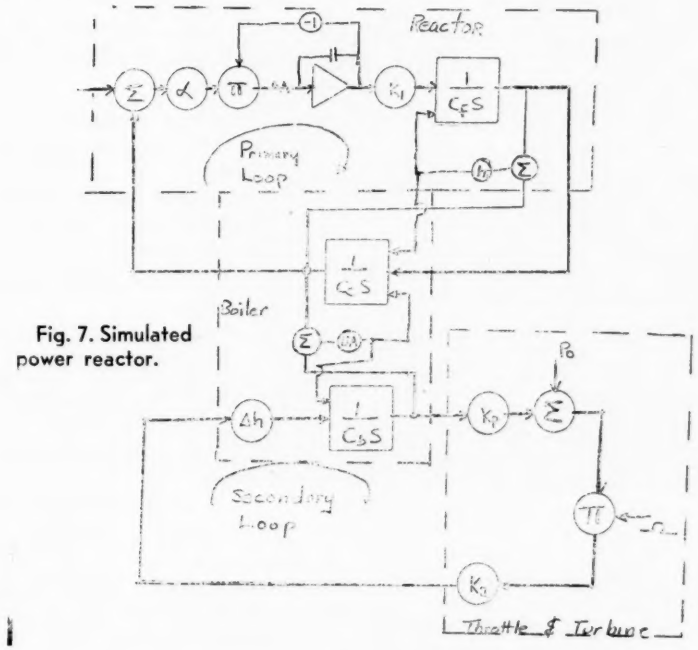


Fig. 7. Simulated power reactor.



The one-group representation of the reactor will not hold for very large values of ΔK because then the prompt neutron lifetime is important. But for much less than prompt critical this is a fine representation.

Consider again the case where 73 out of every 10,000 neutrons were coming from delayed emitters. If reactivity is increased by pulling a control rod so that 73 more neutrons are obtained from the prompt emitters, then the reactor does not have to wait for the delayed neutrons and the neutron concentration increases at a tremendous rate. Now if these 73 neutrons could be taken out, then the reactor could be kept at a steady-state level. In most power reactors the coolant and the moderator are the same thing, which is usually pressurized water. The moderation that a neutron experiences depends on how many hydrogen atoms it bumps into. But as the water in the reactor is heated, the hydrogen atoms get farther apart so that the neutrons experience less moderation and are therefore less favorable for fission. This inherent negative feedback results in the negative temperature coefficient of reactivity of the coolant, which in turn makes it possible to hold a desired temperature very accurately.

In the simulation of the temperatures θ_f, θ_c, and θ_s (temperatures of the reactor fuel, the primary coolant, and the steam respectively), Barnes used the same general formula which states that the rate of change of temperature times the heat capacity is equal to the heat input minus the heat loss. In the case of the reactor fuel temperature, the heat input is proportional to the neutron concentration N. Heat is lost to the primary coolant and the amount lost is equal to a heat transfer coefficient times the temperature difference between the fuel and the coolant.

The heat lost by the fuel is added to the primary coolant.

In the secondary loop the heat loss

due to the turbine load is proportional to the weight rate of steam flow through a throttle valve opening. If the steam pressure is proportional to its temperature, then the equations for the system can be completed.

Information (Without Theory)

We were interested to learn from Hideo Mori's notes that the Eastern Simulation Council's study groups seem to be thriving.

Harold Skramstad's group on **Combined Analog-Digital Simulation** has discussed the current work at National Bureau of Standards to connect their analog facility with the digital computer SEAC to simulate sampled-data systems. They have also considered:

1. The work at Convair and Ramo-Wooldridge, and plans at Holloman Air Force Base, for combining large-scale analog and digital computers for simulating complex missile systems.
2. Relative computing speeds and accuracies of analog and digital computers.
3. The types of calculation which should be done analog-wise, and those which should be done digitally.
4. Advantages and disadvantages of a combined facility as compared with each type alone.

Dr. Morris Rubinoff's (Univ. of Penna., Philadelphia) group on **Fundamentals of Simulation** has considered definitions and interpretations, and as usual the human element enters in. Who determines whether a simulation is a good enough approximation to the system being simulated? To what extent does the path between the system and its representation enter into the definition of simulation? The direct path might be via analog or digital computer with output on a continuous recorder or as a tabulation of data, while the indirect path might be a solution in general or a closed analytic form followed by evaluation of particular cases.

The group on **Future Trends in Simulation** (*Frank Richmond*, The Glenn Martin Co., Baltimore, Md., Chairman) discussed the limitation of non-linear elements and the need for more realistic and uniform specifications in their January meeting. This is particularly important since the introduction of analog computers into industry for use in oil refineries, power distribution systems, process control, etc. In March Frank's group outlined their field of interest as follows:

I. Equipment and arrangements
  A. New and expanded fields of simulation
    1. Combined analogue-digital simulation
    2. Components
  B. Refinements of present equipment
    1. Automatic and digitalized operation
      a. Programming and setup
      b. Checkout and readout
      c. Control
    2. Complete electronic components
    3. Use of special-purpose blocks

II. Application
  A. Simulation of a logic system
  B. Dynamics and simulation for business controls

In January the study group on **Dead Time Simulation** (*Bernie Loveman, Chairman*) reviewed work on abstracts of papers on simulation of dead time in order to compile a bibliography. This included use of linear approximations to dead time and the definition of a best or optimum network. This study group thus terminated work on their subject. In its place a new study group on **Evaluation of Analog Computer Performance** (also chaired by Bernie) plans to discuss performance factors and testing procedures for components of dc electronic analog computers. The effect of component errors on the solution of problems will not be discussed, since that subject falls in the realm of error analysis. Performance factors to be considered are static accuracies, dynamic accuracies, noise, life, and repeatability. Also linear elements such as amplifiers, potentiometers, resistors, and capacitors will be reviewed.

Members who attended the **Physical Simulation Study Group** (*Herb Wexler AVCO, Chairman*) in January discussed the use of flight tables for a performance check on a system after it has gone through environmental testing, and the simulation of forces on an accelerometer. They also talked about pickup and photographic recording.

A new study group on **Process Simulation** has been tentatively organized, to be led by *Ted James* of DuPont.

He Went That-A-Way!

Our friend and Chairman Emeritus of the Western S/C, *Norm Irvine*, is now Senior Dynamics Engineer with the Pomona, California, division of Convair.

Computer Events

Fourth Annual Symposium on Computers and Data Processing

Dates: 29 and 30 August 1957
Place: Denver Research Institute, University of Denver, Denver 10, Col. Write: C. A. Hedberg, Head, Electronics Div., U. of Denver.

Central Simulation Council

Date: 16 September 1957
Place: Boeing Airplane Company, Wichita, Kansas
Subject: "Hardware Tie-Ins"
For information write Harry Cordes, Boeing

Symposium on Analog and Digital Computation and System Dynamics

Dates: 19-20 November 1957
Place: Wright Air Development Center, Wright-Patterson Air Force Base, Ohio
There will be one combined session on topics of interest to all groups, followed by separate meetings on digital computation, analog computation, and system dynamics. For information write A. C. Robinson, Aeronautical Research Laboratory, WCRRY, Wright Air Development Center.

International Simulation Council

Dates: 9-12 December 1957
Place: Washington, D. C.
This will be held in conjunction with the Eastern Joint Computer Conference. For information write Dr. Harold Skramstad, National Bureau of Standards, Washington 25, D. C.

OPTIMIZING CONTROL discussed by *Manny Otis*

Industrial process control today generally consists of a series of unrelated minor control loops. Each loop measures but one variable at a particular time and controls excursions of this variable within predetermined limits from a set-point selected by an operator.

Trends within individual control loops are not obvious —that is to say similarities and dissimilarities in plant operating conditions are ill-defined—and the operator is unable to anticipate with sufficient rapidity interrelationships in such trends. This essentially precludes use of available data to the fullest advantage. Furthermore, it is easy to demonstrate that the limits within which a process variable can be held automatically are several orders of magnitude smaller than can be attained by a human operator in establishing the set-point for such limits. Hence, in making his decisions, the operator is at a marked disadvantage.

All of this leads us to the generalization that processes are controlled, but that the control function is not optimized. And as a rather natural extension of this generalization, if optimum control is incorporated into a process, the efficiency of the process can be expected to increase.

The first step toward this desirable objective has already taken shape with the development of electronic data logging systems. Many such systems are now available to industry. The unavoidable time lag between recording, correlation, and evaluation in such systems is so great, however, that the effectiveness of solutions provided for process control decisions is essentially nil. Hence, the data serve primarily to provide an insight into process dynamics.

In optimizing the continuous process, different variables must not only be sensed but correlated in real time in order to yield control decisions before plant operating conditions have changed appreciably. To achieve this, remedial control decisions must be initiated before the predetermined control-limits have been reached.

Progress in the theory of nonlinear adaptive control is providing the mathematical background necessary to define the necessary correlation procedures; digital computer techniques will play a decisive role in implementing the theory. Closing the loop in a continuous process, therefore, places tremendous demands upon the system's designer. A control system that is to replace a human being must be able to do so continuously and infallibly. Demands for ever greater reliability (one error in several hundreds of millions of decisions) and longer life are achieved with the use of solid state components. And since environmental conditions in industrial processes rarely are controlled as equably as in an office or a scientific computation center, circuit design and packaging requirements must be adapted to the widest range of operating climate.

Emmanuel J. Otis, systems design engineer discusses control optimization

The proper selection and integration of the necessary units required to "marry" the control computer to the process are dependent upon the desired speed and accuracy of the overall system. Hence, specific process requirements must govern the design of the control system in order to achieve the optimum use of equipment. These process characteristics must define speed, degree of accuracy, memory capacity, and flexibility—prime factors that determine the size and complexity, and therefore the price and economic justification for, such control equipment.

In closing the loop, digital computers and attendant devices will optimize industrial process control systems by providing minor control loop set-points. Eventually, minor control loops will be replaced altogether. At that time, control decisions will be made and operating instructions provided by the control equipment to devices that will govern the functioning of process variables.

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Journal of the S C M A . . .

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SPEED CONTROL OF CENTRIFUGAL AND RECIPROCATING COMPRESSORS

This résumé of compressor characteristics indicates the need for variable-speed control and the advantages of speed control with fast-acting speed controllers. Response of typical systems is given in terms of time constants.

C. G. LASPE

The Ramo-Wooldridge Corporation

MODERN continuous processes used in the petroleum and chemical industries are demanding the use of more sophisticated control systems.

The reasons for speed control of centrifugal and rotary compressors will be briefly explored. If the control is inadequate, it may be necessary to install additional horsepower to carry surge loads which occur infrequently and for short periods of time. Precision speed control, however, can accommodate these short-term demand surges by the controlled running of the compressor somewhat above its rated speed. Hence an accurate and fast speed-control system can save not only operating dollars but capital dollars as well!

Centrifugal-Compressor Characteristics

The centrifugal compressor, in most respects, behaves similarly to the well-known centrifugal pump. The volume delivery rate is approximately proportional to the rotating speed; the pressure head developed is proportional to the square of the speed; and the power required is proportional to the cube of the speed.

August Meeting: *Thursday, the 15th; Rio Hondo Country Club, Downey, Calif.*

Feature: *Clive Lawler Wilson, U. S. Electrical Motors Inc., will present a paper on "Use of Electric Motor Current as a Process Indication."*

Fig. 1 illustrates the head-volume curves for a typical compressor running at several speeds. There are two main points of interest shown by these curves. First, there is a rapid dropping-off of the developed head above the rated capacity. Secondly, there is the phenomenon called *surging* or *pumping* which occurs at approximately 50% of the rated capacity. It is beyond the scope of this paper to expound the reasons for compressor surging. Suffice it to say that the surge point represents an operational limit below which the machine becomes unstable. The important point, however, is the fact that surging limits the range of operation of the centrifugal compressor. In other words, the compressor has a rangeability of approximately two to one.

Fig. 2 illustrates the power requirements of the same compressor. Note the similarity to the characteristic curves of a centrifugal pump.

With this brief examination of the peculiarities of the centrifugal compressor the various methods of control will now be investigated. There are two basic methods of operation:

1. Constant speed
2. Variable speed

Constant-Speed Operation of Centrifugal Compressors

Constant-speed operation is generally limited to low-power applications where the potential power savings do not justify the added investment of a variable-

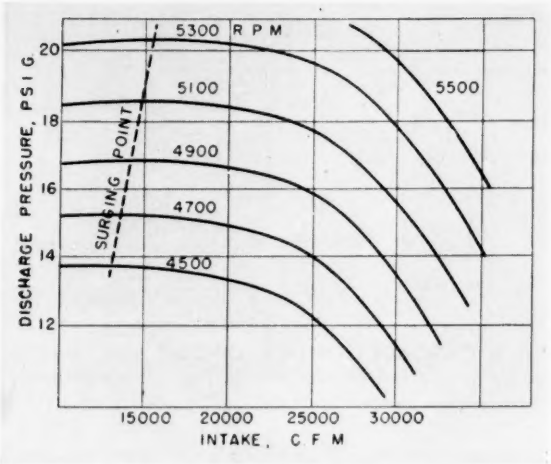

FIG. 1. TYPICAL CENTRIFUGAL-COMPRESSOR characteristics show head vs volume at several speeds. Compressor can become unstable below surging point.

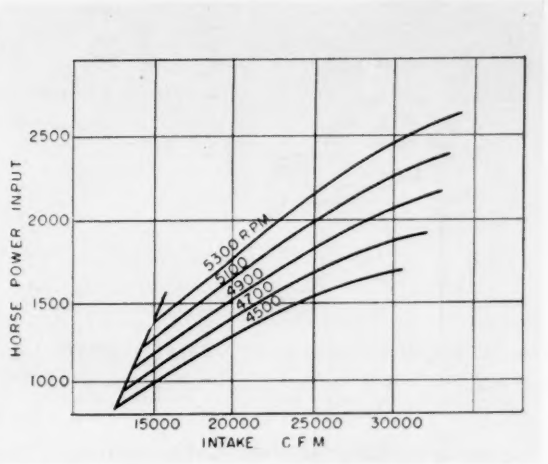

FIG. 2. TYPICAL POWER REQUIREMENTS of the centrifugal compressor of Fig. 1. Operation is always above the surging point.

speed drive and its associated control system. In most instances, a-c synchronous motors are utilized as the prime mover. Such a drive represents a low investment cost and is relatively maintenance free.

Control of both volume delivery and/or pressure from such a system can be accomplished by throttling the compressor discharge. A typical flow-control system is shown in Fig. 3. The basic limitation of the system is in the rangeability of the centrifugal compressor. If load changes occur in greater than a 2:1 ratio, then another type of system must be considered if surging cannot be tolerated.

Rangeabilities as great as 3:1 can be obtained through use of adjustable inlet guide vanes[4] and an integral power-recovery wheel. Such an arrangement consists of a reaction-type turbine wheel coupled to the compressor shaft and physically located ahead of the first stage blower impeller. Not only is the pumping zone reduced to 30-35% of the rated limit, but considerable savings in power are also effected. These savings, however, are not quite as great as can be realized from variable-speed operation.

With high-power installations it becomes economically mandatory to operate the compressor with a variable-speed drive. Fig. 4 shows an example of the savings to be expected for a typical compressor operating with a variable-speed drive. The dotted line in the figure represents a typical system curve. Thus, at a flow rate of 30,000 CFM the system pressure drop requires a power input of 2,500 HP. If the flow rate is reduced to 25,000 CFM a power input of 1,600 HP is required. Now, if the above system were operated at a constant speed of 5,300 RPM the figure shows that, at 25,000 CFM, a total of 2,200 HP would be needed. This means that 600 HP would have to be dissipated across the control valve. It is obvious that the compressor in the above illustration would not be operated at constant speed. However, the illustration shows how the horsepower savings can be evaluated.

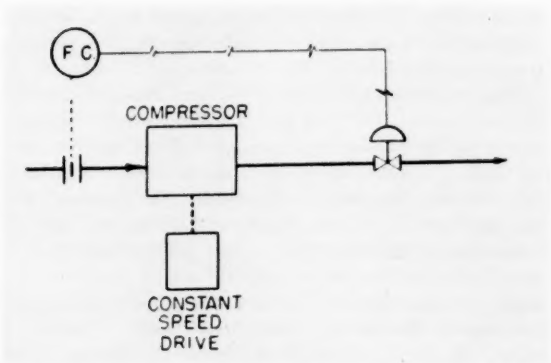

FIG. 3. FLOW CONTROL SYSTEM using constant-speed technique.

Constant-Speed Operation of Reciprocating Compressors

Constant-speed operation of reciprocating compressors will now be considered briefly. Here again on large horsepower installations the use of variable-speed

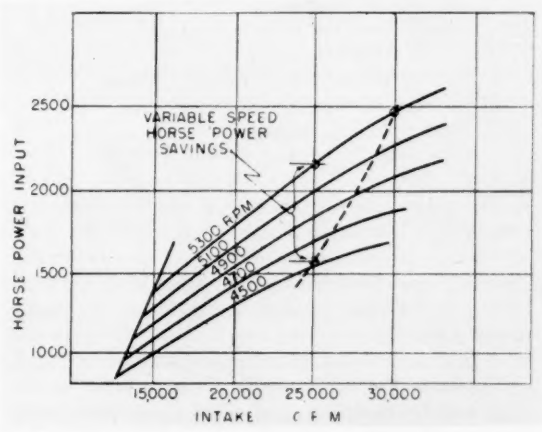

FIG. 4. ECONOMICS OF CONSTANT-SPEED vs variable-speed operation. If system is operating at constant speed of 5300 RPM, 2200 HP is needed to deliver 25000 CFM. However, only 1600 HP will deliver same 25000 CFM at 1600 HP, represent a savings of 600 HP.

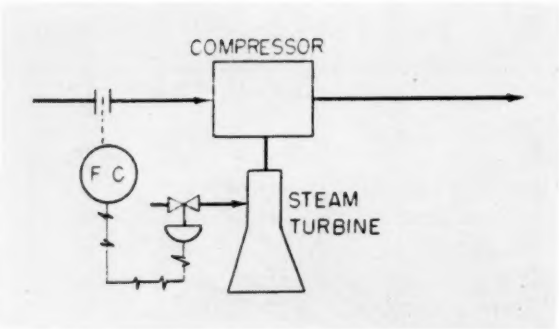

FIG. 5. FLOW CONTROL BY VARIABLE-SPEED drive using a steam turbine to drive the compressor. Control is obtained by throttling the steam to the turbine.

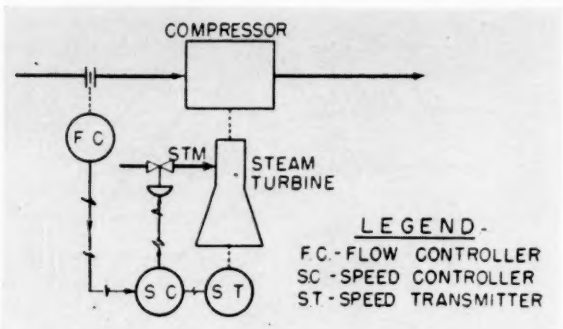

FIG. 6. CASCADE CONTROL CIRCUIT, with speed reset by flow, is better than that of Fig. 5 because speed controller has faster response.

drives is indicated. As a device, the reciprocator has a wide rangeability. It will operate efficiently from its maximum rating to essentially no load when its speed is varied accordingly.

For the moment, assuming constant-speed operation, the pressure or flow of gas from the reciprocator may be controlled by throttling the suction to the compressor. This, in effect, alters the compression ratio. The limit to this type of operation is imposed by the dangerously high discharge temperatures which may be encountered. This is a particular problem where gas containing air is near or at either of its explosive limits.

Where wide load changes are to be encountered it is better to control the constant-speed reciprocator by the use of "unloaders" and/or "clearance-pockets." In these cases, however, the control is stepwise instead of continuous and in some applications may result in on-off or recycling control.

Variable-Speed Operation

The types of drivers suitable for variable-speed operation of compressors are:

1. Steam Turbine
2. Gas Engine
3. Gasoline Engine
4. Diesel Engine
5. Wound-Rotor Electric Motor
6. D-C Motor with
   A. D-C Supply or
   B. Thymotrol Drive

The great majority of applications encountered in the process industries utilize the first two drivers in the above list—the steam turbine or the gas engine. In either case, however, variable speed is accomplished in much the same manner, by throttling the energy input to the device.

A flow control system utilizing a steam-turbine drive is shown in Fig. 5. In this case the variable speed is obtained by throttling the steam supply to the turbine. Such a system is adequate provided that fast load changes and momentary upsets can be tolerated. The control loop contains not only the time constants of the flow control system but the time constants of the turbine and compressor as well. Such a system may be somewhat difficult to control and may not be amenable to the precision required by some compressor-flow applications.

A better arrangement is shown in Fig. 6. Here the speed of the turbine is controlled by a very fast and tight control loop. The speed required is set by the flow controller to complete the cascaded control loop. Such a system is relatively immune to load changes such as a drop or rise in steam header pressure. In addition, with the time constants of the turbine and compressor looped by a fast and tight control system, the flow controller can be adjusted for faster recovery from sudden flow upsets.

Speed Controllers

Until recently the only available speed controllers were the hydraulic governors as supplied by the turbine and engine manufacturers. These governors were generally either:

A. Flyball type or
B. Orifice-operated type

The flyball governor uses a flyball speed-sensing element, the movement of which is mechanically linked to a hydraulic servomotor which in turn positions a steam or fuel valve. These governors are characterized by some hysteresis and limited accessibility and range of control function adjustments. They may incorporate both proportional and automatic reset functions. The proportional adjustments are limited from approximately 50 to 100% of the proportional band. While adequate in most cases, a wider range of settings would be desirable.

The orifice-operated type of variable-speed controller consists of a gear pump which forces a small stream of hydraulic fluid through a fixed and variable orifice in series. The gear pump is directly coupled to a rotating member of the driver. The pressure at the junction between the fixed and variable orifices is a measure of the speed and is used as the input pressure to the hydraulic servomotor which positions a steam or fuel valve. Speed is varied by changing the opening of the variable restriction, usually a needle valve. In the orifice-type hydraulic governor, the precision of speed measurement suffers due to viscosity changes in the hydraulic fluid whenever the

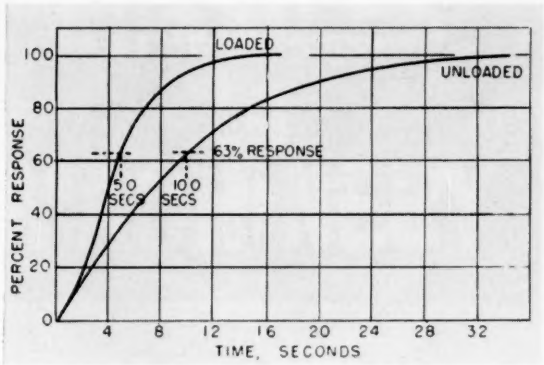

FIG. 7. SPEED RESPONSE of one steam turbine to step change of control valve.

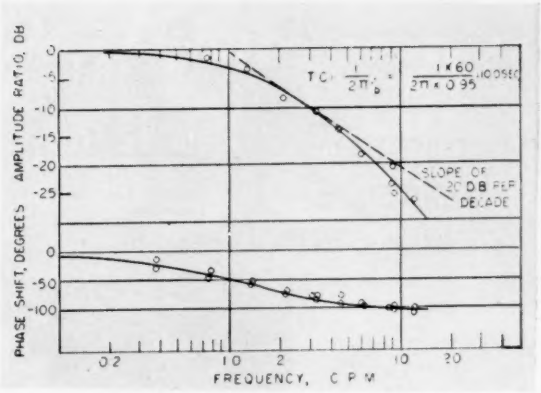

FIG. 8. OPEN-LOOP FREQUENCY RESPONSE of unloaded steam-turbine-driven compressor.

ambient temperature changes. In addition, careful straining of the oil is required to prevent clogging of the restrictions which, of course, would result in erroneous speed measurement.

Terminology also has been a problem. Control actions performed by the hydraulic governors have assigned to them names with which instrument engineers are entirely unfamiliar. Pellettere[2] has eliminated some of the terminological confusion.

Control engineers have long felt the need for a reasonably priced pneumatic speed transmitter which could be connected directly into conventional pneumatic control systems.

Pioneering efforts of the Shell Development Company have led to the recent appearance of a pneumatic speed transmitter. This device has been subjected to exhaustive field tests on all types of driver-compressor combinations.

Essentially, the pneumatic speed transmitter[3] is a force-balance device in which a force generated by a set of flyballs is opposed by the pneumatic force created in a bellows. A nozzle-flapper arrangement is used as an equilibrium position detector and prime source of the pneumatic feedback signal.

In use, the transmitter converts rotating speed to an equivalent 3-15 psig pneumatic signal. This signal may then be used to operate conventional pneumatic controllers having an extremely wide range of adjustments which can be made to fit almost any control application.

As the centrifugal force developed by a pair of flyballs is proportional to the square of the speed, and as this force is opposed by the transmitted air pressure, it is readily apparent that this pressure is proportional to the square of the speed. Thus a conventional square-root chart can be used to record the speed.

Speed ranges of 0-600 to 0-1600 RPM can be accomplished by adjusting the position and/or weight of the flyballs. Higher or lower speeds may be measured through the use of gear boxes.

Zero suppressions of 65 to 90% of the span can be accomplished by pre-loading the force-balance bellows with an adjustable spring. With these amounts of zero suppression, linear charts can be used with errors of less than 2% of the indicated speed.

One other advantage of the pneumatic speed transmitter is the fact that a speed record is easily obtained.

Response Characteristics of Speed-Control Systems

The dynamic response characteristics of the complete system must be known if functions are to be selected for a given application.

Fig. 7 shows the transient responses of a steam turbine driving a centrifugal compressor upon a step change in steam valve setting.

Note the difference in response of the system when the compressor was loaded as compared with the unloaded condition. The 65% response times are, respectively, 5 seconds and 10 seconds for the loaded and unloaded conditions. This difference in the time responses is by no means a general rule. (Test data on other turbine-compressor combinations have shown no dependence upon load. In some cases, even the reverse effect may be true—especially in engine-driven reciprocators.)

An open-loop frequency response curve[5] corresponding to the above step response is shown in Fig. 8. This compressor-turbine combination can, for practical purposes, be considered as a first-order system with a time constant of 10.0 seconds. This checks well with the value obtained from the step response. There is some indication (from the amplitude ratio curve) that a second time-constant is in the picture. This is not entirely borne out by the phase-shift curve since a maximum shift of only 100° was observed. There is the possibility, however, that the phase curve might curve downward if the tests were extended to higher frequencies.

The frequency-response data on this same compressor when loaded showed a 3.0-second time constant and, again, a first-order system. This agrees fairly well with the 5.0 seconds obtained from the step response.

In general, it may be stated that steam-turbine—centrifugal-compressor combinations show a major time-constant in the range of 1 to 5 seconds. Secondary time constants, if present, are on the order of 0.1 to 0.5 second. Typical values[5] are compared in Table 1. Also shown is a comparison of gas-engine-driven compressors and a diesel-driven centrifugal pump. The gas engines appear to be first-order systems with about 1-second time constant. Considerable dead time (D.T.) also is present.

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TABLE 1—COMPARISON OF VARIOUS SPEED-CONTROL SYSTEMS.

System	Description	Time Constants	Controller Settings P.B.	Controller Settings R.R.
I	Centrifugal Compressor Turbine Drive	5.3, 0.4 Secs.	75%	12 RPM*
II	"	1.0, 0.2	30	50
III	"	3.0	50	50
IV	2 Cycle Gas Engine, Recip. Compressor	1.2 0.6 D.T.	130	20
V	"	1.0 0.3 D.T.	—	—
VI	Diesel Engine Centrifugal Pump	Est. 12 Secs.	26	12

*Repeats per minute

speed control? All the systems are relatively fast. As a general rule, the shorter the time constant the higher the reset rate which can be used. This in turn means quick recovery from transient upsets with little control-point offset. On the other hand, due to the short time-constants involved, a point is being reached where limitations may be imposed by the response of the pneumatic control equipment. Transmission line characteristics and booster pilots then must be considered.

It will be noted in the above figure that reset rates in the order of 12 to 50 repeats per minute were used. In the case of the steam turbines, the maximum useable reset rate was limited by the major time constant. In the care of the gas engines, the dead time was the limiting factor.

It is interesting to note that the use of rate action in the speed control loop may be beneficial to the cascade control system. Derivative times on the order of 0.001 to 0.005 minute are of the approximate magnitude to be used. Unfortunately, most pneumatic controllers are ineffective at these low rate times.

Conclusions

For economic reasons, variable-speed drives for compressors are indicated. Accurate control of speed is necessary to keep down operating and investment costs. This can generally be accomplished by the use of cascaded speed-control systems. Speed-control loops are fast. Their time constants are generally of the same order of magnitude as some flow and pressure control systems. By looping one of the major time constants the cascade system has proved beneficial in providing stable and responsive control. Precise speed control can be accomplished through the use of conventional pneumatic control equipment which is readily understood and maintained by the average instrument mechanic.

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3. "Instructions for Taylor Pneumatic Speed Transmitter," Taylor Instrument Cos. Bulletin 92204.
4. "Turbo Blowers for Bessemer Converters," Ingersoll-Rand Bulletin No. 8012
5. B. D. Stanton, and A. Bremer, "Private Communication," Shell Development Co., Emeryville, Calif.

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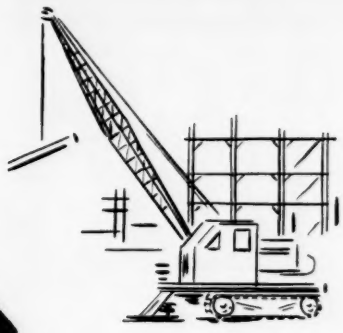

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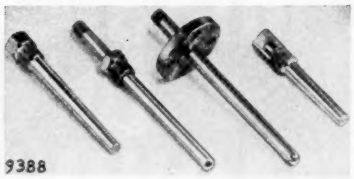

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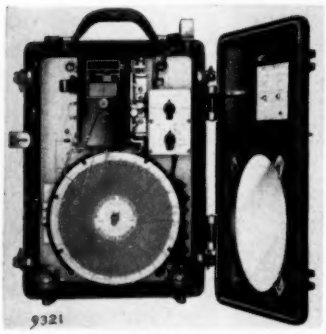

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New portable millivoltmeter recorders for survey work have movement sensitivities 2,000 or 10,000 ohms per volt. Each instrument has eight ranges; chart drives that rotate the 8" chart in 96 min or 24 hr also are available.—*The Bristol Co., Waterbury 20, Conn.*

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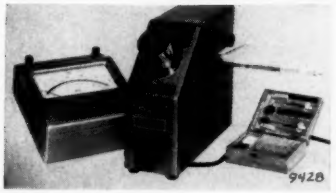

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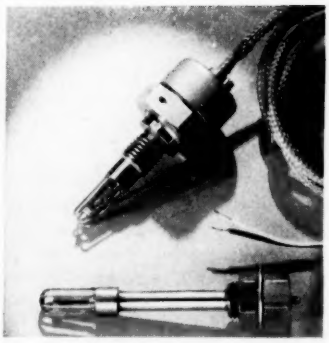

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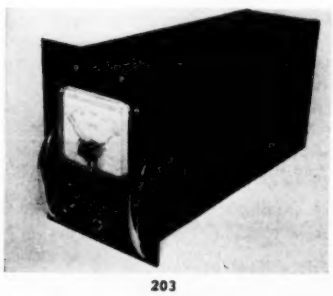

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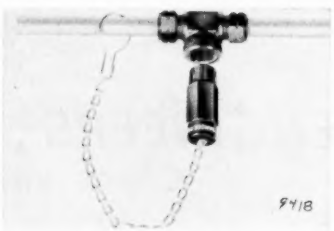

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TEMPERATURE

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New WEKA micro melting-point tester is constructed as a projection microscope so that several persons can simultaneously observe melting process on large ground-glass plate. Observation with polarized light also is possible. Can be supplied either with thermometer or thermo element and galvanometer. Maximum melting temperature is 900°F (480°C).—*Epic, Inc.*, 154 *Nassau St., New York* 38, *N. Y.*

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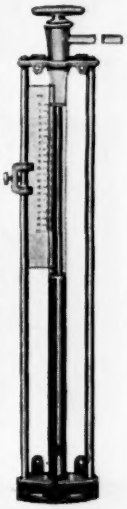

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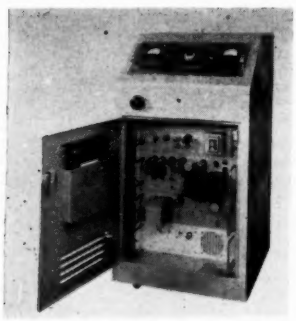

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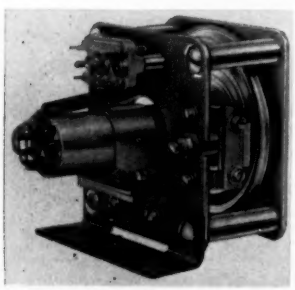

213

214

piping and fittings, cleaning valve, back flushing requirement, troublesome float cable. Float is immersed only ½"; as ⅞ of float is out of the water, sewage and debris can ride through without becoming engaged with float itself.—*Burgess Manning Co., Penn Instruments Div.*, 4110 *Haverford Ave., Phila.* 4, *Pa.*

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PRESSURE TRANSDUCER

New Pressure Transducer converts a 3-15 psi signal to a-c millivolts directly proportional to the pneumatic input. When pressure is applied to the sensing element of the transducer, the resulting movement of an expandable capsule displaces an armature which induces opposing voltages in twin secondary coils. Accuracy is 0.25% of full scale.—*Fischer & Porter Co.*, 93 *Jacksonville Rd., Hatboro, Pa.*

For more information circle **213** on inquiry card.

LEAK DETECTOR

New Model 4902 low-cost leak detector is operated by connecting to evacuated part with outside blanketed with Freon-12 as tracer gas. If leak is indicated, further probing with a fine stream of tracer gas locates leak. Unpredictable slow shift in "no-leak" signal has been eliminated by measuring rate-of-change of signal rather than its absolute value; recovery time from exposure to tracer gas has been sharply decreased by continuously flushing the sensing element with halogen-free air.—*NRC Equipment Corp.*, 160 *Charlemont St., Newton Highlands, Mass.*

For more information circle **214** on inquiry card.

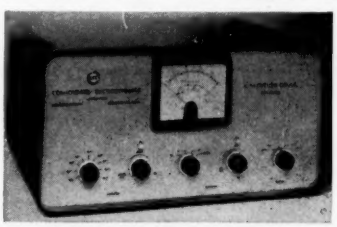
U-TUBE MANOMETERS

New Series 1225 low-cost manometers for light pressure and vacuum are available in 6", 12", and 18" with either straight or inverted U top for connecting rubber tubing. Double columns are clear heavy-walled Butyrate plastic tubing; scale assembly is adjustable vertically for zeroing.—*F. W. Dwyer Mfg. Co., P. O. Box* 373, *Dept IAN, Michigan City, Ind.*

For more information circle **215** on inquiry card.

IONIZATION GAUGE

New GIC-100 ionization vacuum gauge gives continuous pressure readings on eight linear ranges from



1×10^{-3} to 2×10^{-12} mm Hg. Emission control is variable over a continuous linear range from 25 microamperes to 20 milliamperes, and is regulated throughout the range to ±2%. Tube degassing by both resistance and electron bombardment is provided. Accessory two-station thermocouple circuit is available with a range from 1 to 1000 micron Hg.—*Consolidated Electrodynamics Corp.*, 300 *North Sierra Madre Villa, Pasadena, Calif.*

For more information circle **216** on inquiry card.

High Sensitivity Micro-Differential PRESSURE METER

Completely Self-Contained

no accessories required

Measures

A WIDE RANGE OF **STATIC & DYNAMIC**

pressure of gases and other non conducting fluids. Includes provisions for oscilloscope viewing and recording on an optical oscillograph or a direct writing recorder.

Determines

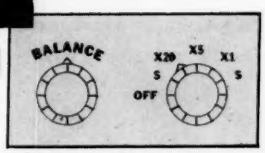
VARIATIONS OF **PRESSURE, VOLUME**

temperature, fluid flow, expansion, absorption, adsorption, chemical alterations, altitude, vacuum, etc.

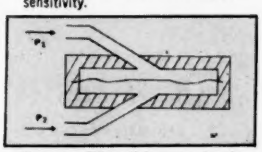
Provides

ONE MICRON OF MERCURY **RESOLUTION**

at any ambient pressure up to 2 atmospheres. 7.5 volts output available for recording at full scale differential pressure of 1 mm of mercury.

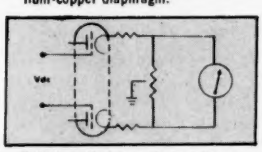


Two-knob control for balance, . . . sensitivity.

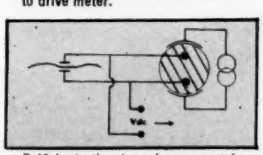


Pressure differential moves beryllium-copper diaphragm.

Utilizes the T-42 IONIZATION TRANSDUCER



Output applied to cathode follower to drive meter.



T-42 Ionization transducer converts motion into electrical signal.

This unusually simple pressure instrument is completely self contained. It requires no special accessories, additional equipment or trained personnel for operation. Merely plug this compact instrument (only 5" x 5" x 10") into the 115 V, 60 cy. line and in 2 minutes it is ready for use. Two knob control . . . for balance and sensitivity.

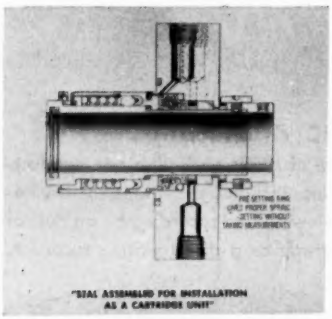
It is an extremely versatile and truly valuable accessory for any laboratory.

Details on this new micro-sensitive meter are in Instrument Data Sheet 303-1, available upon request to Technical Literature Section.

DECKER AVIATION CORPORATION

Philadelphia, 25

For more information circle **66** on inquiry card.



217

MECHANICAL SEALS

New development provides a seal assembled as a cartridge unit ready for installation. No field fitting is required. Pre-setting ring is attached to the shaft sleeve collar with a setscrew in a slot of controlled length. "Packaged" seal is slipped onto the shaft and into the stuffingbox. Seal flange is bolted to the stuffingbox and the shaft sleeve collar fastened to the shaft. Pre-Setting Ring is then moved the length of the setscrew slot and locked in place. This places the seal in precise running position with spring compressed to proper tension.—*Bryon Jackson Pumps, Inc., P. O. Box 2017A, Terminal Annex, Los Angeles 54, Calif.*

For more information circle **217** on inquiry card.

218

PLASTIC METERING PUMP

New "Auto-Air Plastic Dispenser" pumps and delivers exact quantities of epoxy and polyester resins and hardeners for fiberglass fabrication; will deliver a quantity as small as 10 grams. Maximum output—3lb/min.—*Auto-Air Industries, Inc., 706 Sheridan St., Lansing, Mich.*

For more information circle **218** on inquiry card.

219

DIAPHRAGM SEAL

New silicone-impregnated "LPF" diaphragm seal has been found to have only 1% compression set after months of use; retains maximum flexibility over a temperature range of −150°F to 400°F.—*Bellofram Corp., Burlington, Mass.*

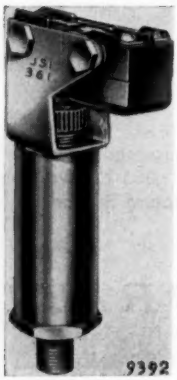
For more information circle **219** on inquiry card.

220

DIFFERENTIAL SWITCH

New "Model 2273" senses pressure differences from 15" H_2O below atmospheric pressure to 80" H_2O above. Switch actuation setting from 0.2" to 2". Reference pressure must be air or an inert gas; variable pressure can be liquid or gas. Switch is not sensitive to jarring or vibration and will operate in any position; incorporates a UL-approved sp-dt snap action switching element; has a splash-proof housing.—*Barksdale Valves, Pressure Switch Div., 5125 Alcoa Ave., Los Angeles 58, Calif.*

For more information circle **220** on inquiry card.



221

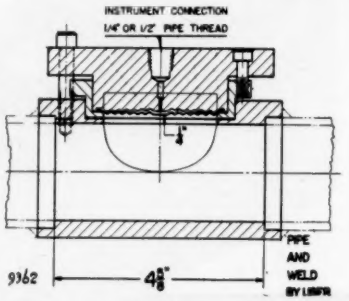
PRESSURE CONTROLLER

New Type J51 pressure-vacuum control, for applications where space and weight are limited, comes in four models having adjustable ranges of 50, 75, and 250 psi between 0 and 350 psi limits. On-off differentials between limits of 5 and 10 psi, dependent on model.—*United Electric Controls Co., 79 School St., Watertown, Mass.*

For more information circle **221** on inquiry card.

PRESSURE-TAP SEALS

New Type AM in-line or flush diaphragm seals provide a minimum cavity (being close to flow stream) to



prevent deterioration of a product from process material hardening or changing state in a cavity. All sizes from ¾" through 2" are offered in steel, 304 stainless steel and 316 stainless steel.—*Mansfield & Green Inc., 1051 Power Ave., Cleveland 14, Ohio.*

For more information circle **222** on inquiry card.

AIR SAMPLING DEVICE

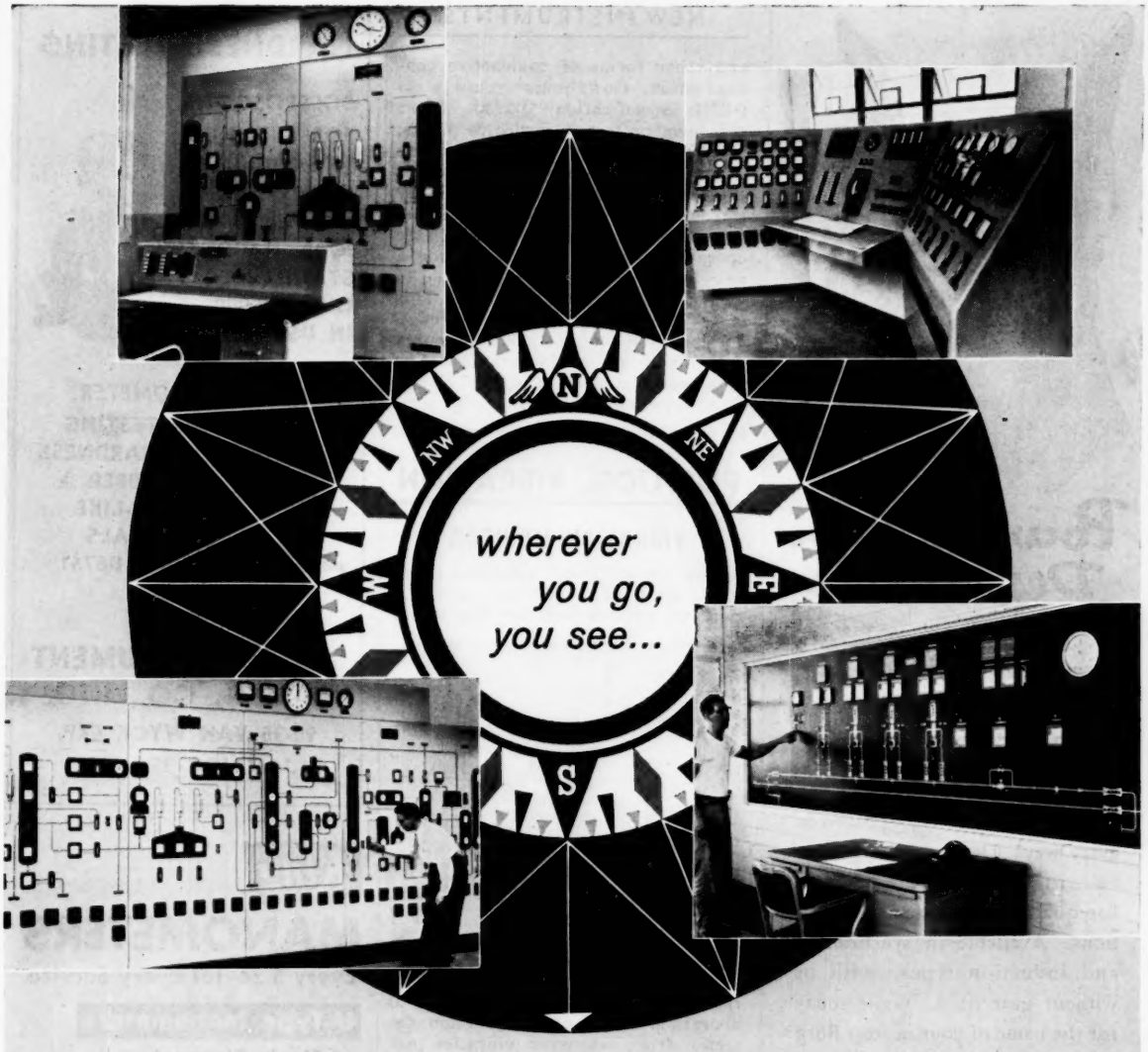
New Model 175 air sampling device weighs less than 2 lb. Principal advantages are small size and built-in

explosion-proof power source—a can of low-pressure liquefied gas linked to a micro Venturi. Sampler developed by E. I. du Pont de Nemours & Co.—*Union Industrial Equipment Corp., 175 Main St., White Plains, N. Y.*

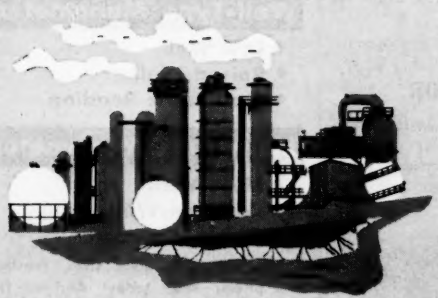
For more information circle **223** on inquiry card.

AIR PARTICLE MONITOR

New Model 900-2 mobile air particle monitor continuously monitors and records radiation level of fall-out



Swartwout AUTRONIC® CONTROL SYSTEMS



Refineries . . . processing plants . . . nuclear installations...pipelines—wherever you go, you'll find Autronic controls by Swartwout, pioneer and leader in the *all-electronic* control field.

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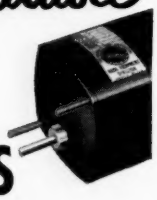
For more information circle **67** on inquiry card.

Powerful... Dependable

BORG-MOTORS



Borg-Motors have been proven in every way! Dependable...powerful...rugged! They are designed for quality instrument applications. Available in synchronous and induction types...with or without gear train. Write today for the name of your nearest Borg Jobber or "Tech-Rep"!

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- Motor mounted on two ball bearings for long life . . . accuracy!
- Precision gears!
- Eight models to meet your requirements!
- Production quantities available!

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MOTORS
MICROPOTS
MICRODIALS

BORG EQUIPMENT DIVISION
THE GEORGE W. BORG CORPORATION
JANESVILLE, WISCONSIN

For more information circle **68** on inquiry card.

NEW INSTRUMENTS

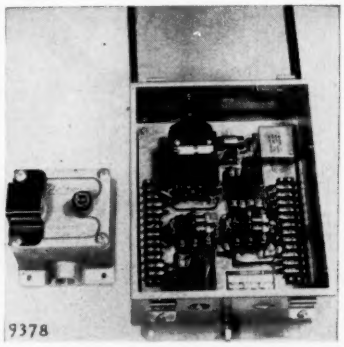
and other forms of radioactive contamination. Conforms exactly to ORNL specification Q-1740. Uses: personnel protection device in plants, laboratories and other facilities where airborne radiation may exist. Built-in alarm system automatically warns of dangerous beta and gamma levels, and is designed for fail-safe operation. Design features include a new logarithmic count rate meter to ORNL specification Q-1454-B. This gives a wide dynamic range of 5 decades from 10 to 1,000,000 counts per minute on a single scale.—*The Victoreen Instrument Co., 5806 Hough Ave., Cleveland 3, Ohio.*

For more information circle **224** on inquiry card.

POSITION, VIBRATION

VIBRATION MONITOR

New non-electronic vibration monitor is sensitive to increases in vibration but ignores both starting vibration and transient shocks normal to operation. Model 65 malfunction detector trips whenever vibration exceeds preset vibration level; Model 651 control unit must reset detector in rapid sequence several times before shutdown time-delay relay (selected for a 2- or 2-or 5- sec delay) will actuate.—*Fielden Instrument Div., Robertshaw-Fulton Controls Co., 2920 N. 4th St., Phila. 33, Pa.*



For more information circle **225** on inquiry card.

POSITION SENSOR

New Model SCI 400 is designed to detect correct position or size of metalic objects without contact. Unit not only recognizes an error, but also

HARDNESS TESTING

SCLEROSCOPE
FOR TESTING THE HARDNESS OF METALS. PIONEER AMERICAN HARDNESS STANDARD. OVER 40,000 IN USE.

DUROMETER
FOR TESTING THE HARDNESS OF RUBBER & RUBBER-LIKE MATERIALS (ASTM D676)

SHORE INSTRUMENT & MFG. CO., INC.
90-35 VAN WYCK EXP.
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For more information circle **69** on inquiry card.

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MANOMETERS
Every Size-for Every Service

U-Type Manometers
- Single Cleanout
- Single Gland-Packed
- Double Cleanout
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- High Pressure

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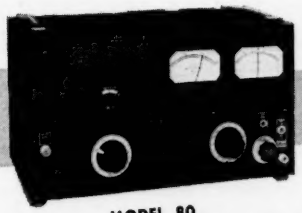
For more information circle **70** on inquiry card.



MODEL 80

STANDARD SIGNAL GENERATOR

2 Mc to 400 Mc

Individually calibrated Direct Reading Scales and Dials

A completely self-contained instrument with built-in power supply and modulator—provides accurate test signals for testing varied radio and television equipment; for laboratory work, production testing, and servicing.

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Laboratory Standards

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For more information circle **71** on inquiry card.

READ TEMPERATURES **INSTANTLY**

with the improved

PYRO OPTICAL PYROMETER

- **Accurate**
- **Direct reading**
- **Rugged**
- **Standard ranges 1400° F to 7200° F**

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PYROMETER INSTRUMENT CO., INC.

BERGENFIELD 4, NEW JERSEY

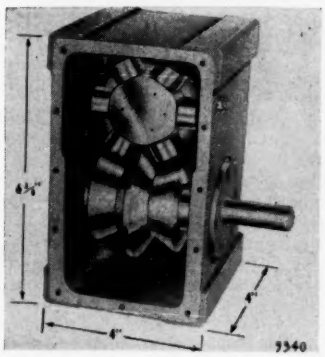
For more information circle **72** on inquiry card.

indicates how the sensed object is wrong—either too far from, or too near to, a predetermined position or setting; Control either stops the machine, rejects the objects, or actuates correcting mechanisms. Element can detect objects up to 2" away; at close proximity can recognize deviations of $1\frac{1}{16}$".—*Security Controls, Inc.*, 257 *Franklin St., Buffalo* 2, *N. Y.*

For more information circle **226** on inquiry card.

INDEXING DRIVES

New E series roller gear drives for high-speed precision indexing, are rated for 2,000 indexes a minute; are

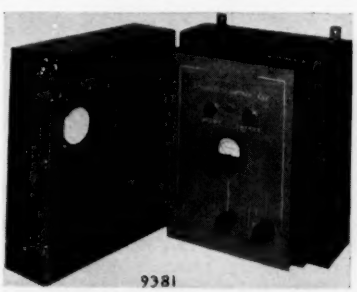


available from stock with 3, 4, 6, 8 and 12 stops and with indexing periods of 120°, 180° and 270°. Housings are as small as $6\frac{5}{8}$" x 4" x 4". Units are rated for minimum of 8,000 hrs; employ modified trapezoid acceleration characteristic for vibration-free indexing.—*Ferguson Machine Corp. of Ind., Roller Gear Div., P. O. Box* 5841, *St. Louis* 21, *Mo.*

For more information circle **227** on inquiry card.

CAPACITANCE-TYPE SHUT-OFF

New 500-1A safety control sets up a field around danger area so that a person, or person's hand, in this area



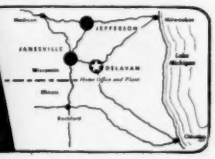
causes machine braking mechanism. Size and shape of safety field are determined by positioning sensing element and by control adjustments. Failure of any electronic component causes machine to stop.—*Security Controls, Inc.*, 257 *Franklin St., Buffalo* 2, *N. Y.*

For more information circle **228** on inquiry card.

WHO IS BORG?

Borg is a highly respected name in its field . . . the manufacture of components for systems. Borg has gained wide recognition as a supplier of electronic components for military and commercial uses.

BORG PLANTS



Borg manufacturing plants are centrally located about 90 miles from Chicago. Easily accessible by highway, rail and air.

WHAT BORG MAKES

Precision Is Our Business. For many years Borg has been prominent in the design and manufacture of precision components for systems.

- **AIRCRAFT INSTRUMENTS**
  Aircraft components, instruments and electronic sub-assemblies.
- **FREQUENCY STANDARDS**
  Crystal controlled oscillator type frequency standards.
- **POTENTIOMETERS**
  Quantity production of Borg MICROPOTS (precision potentiometers) to meet your specifications.
- **MICRODIALS**
  Precision MICRODIALS for single and multi-turn devices. Indexed accuracy of up to one part in 1,000.
- **INSTRUMENT MOTORS**
  Precision motors, synchronous and induction types. Gear trains.

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For more information circle **73** on inquiry card.

PALMER
MERCURY ACTUATED

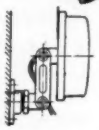
DIAL THERMOMETERS

in 3 types to suit any requirements

Full 4½" dial face. Stem can be placed at any angle and case can be rotated to any readable position.

1 **Rigid Stem Dial Thermometer** tapered bulb, interchangeable with standard industrial thermometer separable socket. (As illustrated above.)

2 **Wall Mounted Dial Thermometer** with flexible connecting armor. Case adjustable to easy reading position.



3 **Flush Mounted Dial Thermometer** for panel mounting with flexible connecting armor.

All three types have a full 4½" dial face.

for accuracy: Mercury actuated . . . Fully Compensated by Invar Compensaton. Guaranteed Accurate 1 scale division.

for angularity: Can be adjusted to most readable position at any angle desired.

for readability: Bold Black Numbers . . . 11" of scale Reading Dial face can always be placed in easiest readable position.

for interchangeability: Always specify "PALMER" Separable sockets as they are interchangeable for Dial or Industrial type Thermometers.

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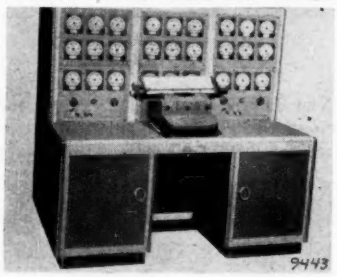
PALMER
THERMOMETERS, INC.
Norwood Ave., Cincinnati 12, Ohio
Mfrs. of Industrial Laboratory Recording and Dial Thermometers

For more information circle **74** on inquiry card.

COMPUTING, DATA HANDLING

MULTI-CHANNEL DATA SYSTEM

New miniaturized multi-channel simultaneous data system receives analog inputs from any number of primary sensing elements, and pre-

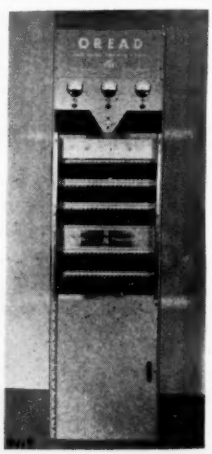


sents decimal digital data on all channels simultaneously. Each channel uses Bristol miniature Dynamaster indicator with analog-to-digital converter in original instrument housing. All channels can be balanced and digital data set up in as little as one second. The decimal digital data can operate directly any parallel entry printer, card punch or tape punch.—*Hanson-Gorrill-Brian, Inc., 85 Hazel St., Glen Cove, N. Y.*

For more information circle **229** on inquiry card.

SHAFT-POSITION ENCODER

New OREAD all-transistor device converts shaft rotation into decimal numbers. Consists of; (1) mechanical-to-electrical converter, (2) logic and



gating circuits and (3) a bidirectional binary-coded decimal counter. Digitalizer operates photoelectrically with two phototransistors, two incandescent lamps, and a light-chopping plastic disc. In logic and gating circuits, the phototransistor outputs are squared, differentiated and gated into two pulse output lines. The output pulses are summed in a bidirectional binary-coded decimal counter.—*Cubic Corp., 5575 Kearny Villa Rd., San Diego 11, Calif.*

For more information circle **230** on inquiry card.

PUNCHED CARD CONVERTER

New Model 251 punched card converter designed to operate with maker's Model 200A Plotter operates without modification with inputs from IBM Type 523 Summary Punch. Contains two sets of resistors which serve as input transducers for X and Y axes of 200A Plotter; commands plotter to plot the point when null is reached on both the X and Y servomotors and also signals IBM machine to feed the next card through the reading brushes.—*Librascope, Inc., 808 Western Ave., Glendale 1, Calif.*

For more information circle **231** on inquiry card.

DIGITAL-to-ANALOG CONVERTER

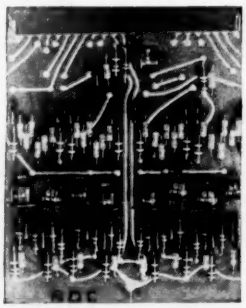
New converter utilizes external standard voltage sources to provide outputs from four output potenti-

ometers. Standard output resolution is 0.05% of full scale. Output accuracy is dependent upon the standard voltage source and can be held to ±0.1% of full scale when 0.05%-linearity potentiometers are used.—*Litton Industries, 336 N. Foothill Rd., Beverly Hills, Calif.*

For more information circle **232** on inquiry card.

BINARY DECIMAL COUNTER

New Model BDC-1 high-speed transistorized counter utilizes a gated binary circuit reset to zero on the

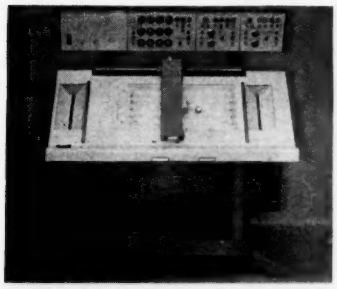


count of 10. Unit is packaged as a printed circuit card with input, output and reset available. Accessory cards are available for readout and preset. Counter cards can be used in multiple each driving a succeeding stage from its output. Each is only 4-1/2" x 5". Power requirements are 12 volts at 14 ma, 6 volts at 1.4 ma and −12 volts at 1.8 ma. Maximum speed is 500 kc.—*Ransom Research, P. O. Box 382, San Pedro, Calif.*

For more information circle **233** on inquiry card.

OSCILLOGRAM READER

New Oscillogram Reader presents new concept in data reduction. Reads opaque or translucent oscillograms,

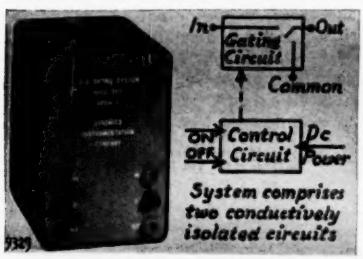


automatically corrects for nonlinearity, and prepares data for either plotting, typing, tape perforating or card punching. Equipment is incorporated into desk-type console. 12" x 24" exposed reading area accommodates records 13" wide with a 6" diameter roll.—*Telecomputing Corp., 16217 Lindberg St., Van Nuys, Calif.*

For more information circle **234** on inquiry card.

DC GATING SYSTEM

New line-powered or battery-powered sp-dt switch, capable of transition in less than 10 μsec, is particu-

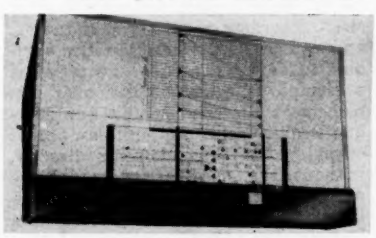


larly useful where an electronic switch is too inaccurate and a mechanical relay too slow. Long life, high reliability and exceptionally small d-c errors are claimed that make it suited for accurate multiplexing of critical analog signals.—*Dynamics Instrumentation Co., 1118 Mission St., So. Pasadena, Calif.*

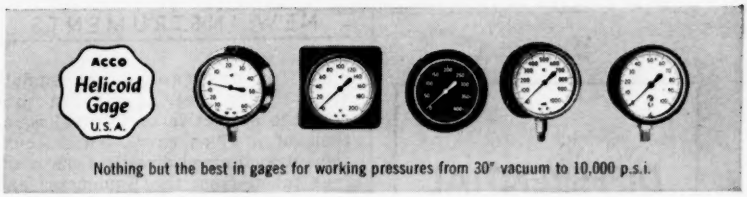
For more information circle **235** on inquiry card.

EQUAMETER

New Model GEQ-450 "Equameter" is manually operated computing device which performs harmonic an-

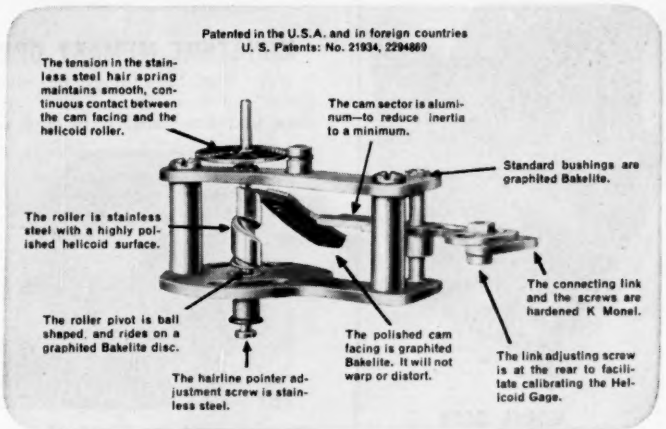


alyses and curve fittings on plotted or recorded curves. Can analyze a curve in terms of fourier series, power



Nothing but the best in gages for working pressures from 30" vacuum to 10,000 p.s.i.

These details of Helicoid gage design assure longer life and enduring accuracy


Patented in the U.S.A. and in foreign countries
U. S. Patents: No. 21934, 2294889
The tension in the stainless steel hair spring maintains smooth, continuous contact between the cam facing and the helicoid roller.
The cam sector is aluminum—to reduce inertia to a minimum.
Standard bushings are graphited Bakelite.
The roller is stainless steel with a highly polished helicoid surface.
The connecting link and the screws are hardened K Monel.
The roller pivot is ball shaped, and rides on a graphited Bakelite disc.
The polished cam facing is graphited Bakelite. It will not warp or distort.
The link adjusting screw is at the rear to facilitate calibrating the Helicoid Gage.
The hairline pointer adjustment screw is stainless steel.

The superiority of Helicoid Gages is most evident in severe service—wherever a gage is subjected to violent pressure pulsations or severe mechanical vibrations.

The *sustained accuracy* of Helicoid Gages over *millions of cycles* is explained by the details of design and construction of the Helicoid movement shown above. Such Helicoid features—protect against wear and corrosion and assure sensitivity, sustained accuracy and trouble-free operation.

Easiest adjustment and calibration

Only Helicoid Gages have the external pointer adjustment pictured here. The Helicoid type adjustment cannot be jarred out of position.

Calibration of Helicoid Gages is accomplished easily, without removing dial or pointer, because the link adjusting screw is at the rear of the system.

Tubes built for millions of pressure pulsations

To fit the wide range of applications, Helicoid Bourdon tubes are available in four materials —alloy steel, K Monel, stainless steel and phosphor bronze.

All Helicoid tubes are made from seamless tubing and are carefully designed to give maximum torque and minimum stress. When used within the dial range, they will withstand many millions of pressure pulsations and will not stretch, leak or crack.

For complete information on the Helicoid line of gages write for **Catalog G-52**

Helicoid gives you all these features at prices that are competitive in the quality gage field.

Helicoid Gage Division
AMERICAN CHAIN & CABLE

929-B Connecticut Avenue • Bridgeport 2, Connecticut

ACCO TRADE MARK

For more information circle **75** on inquiry card.

Dynisco

DIFFERENTIAL PRESSURE TRANSDUCER

MODEL DS2S

Incorporates Unbonded Strain Gage With Four Active Arms

HIGHLIGHTS

HIGH NATURAL FREQUENCY

½% ACCURACY

LINE-PRESSURES to 2000 psi

LOW VOLUME DISPLACEMENT

AC OR DC

MINIATURE SIZE

TEMP. COMPENSATED

PRESSURE RANGES 0-3 to 0-1000 psid

For more information on Dynisco pressure, force, flow, and displacement pickups,

write:

DYNAMIC INSTRUMENT CO.

28 Carleton Street

Cambridge 42, Mass.

UN 4-7260

For more information circle **76** on inquiry card.

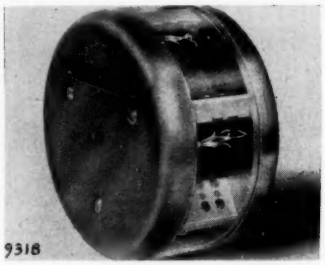
NEW INSTRUMENTS

series, or orthogonal polynomials (least-square fits). It will also produce the derivative or integral equations of a given curve. These equations are obtained directly from readings taken from the Equameter and recorded on specially designed data sheets—all this can be done by an engineering aide with little or no mathematical background.—*The Gerber Scientific Instrument Co.*, 162 *State St., Hartford 3, Conn.*

For more information circle **236** on inquiry card.

MINIATURE MEMORY DRUM

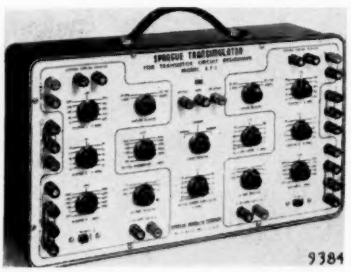
New miniature magnetic memory drum can store over 12,000 bits of data and associated clock and reference information; Standard drum, 3-½" dia, contains 12 information channels plus clock and fiducial channels. Each channel is 0.07" wide with a capacity of 1024 bits; speeds are up to 15,000 rpm; access time is about 1.25 ms. Outside case is 6" dia. by 3-¼" wide.—*BJ Electronics, Borg-Warner Corp.*, 3300 *Newport Blvd., Santa Ana, Calif.*



For more information circle **237** on inquiry card.

TRANSISTOR CIRCUIT SIMULATOR

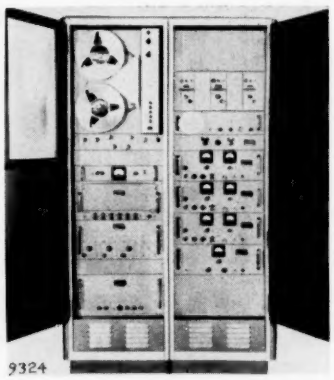
New LF-1 Transimulator does away with breadboard layout by simulating complete transistorized amplifier stages. Any ac or direct-coupled amplifier stage can be simulated, as can multivibrator, switching, phasing, push-pull, Class A and B circuits, and others by using cross-coupled transimulators. Common or grounded emitter, base, or collector circuits may be simulated using *p-n-p*, *n-p-n* or surface barrier transistors. A separate transimulator can be used for each stage to permit simultaneous multi-stage operation, or circuits can be simulated stage-by-stage for cascade operation.—*Sprague Products Co.*, 409 *Marshall St., North Adams, Mass.*



For more information circle **238** on inquiry card.

MAGNETIC TAPE SYSTEMS

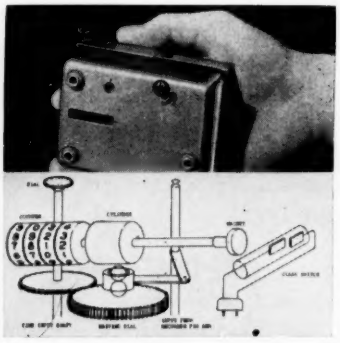
New "Universal Tape Systems" meet individual data-recording requirements by providing a selection from standard transports, heads, and recording/playback equipment and combining these components in standard racks. Standard transport offers six tape speeds, is available for 1" or 1½" tape, on 10½" or 14" reels. Electronic wow-and-flutter compensation systems are easily accommodated. —*Davis Lab Div., Minneapolis-Honeywell Regulator Co.*, 10721 *Hanna St., Beltsville, Md.*



For more information circle **239** on inquiry card.

LINEAR INTEGRATOR

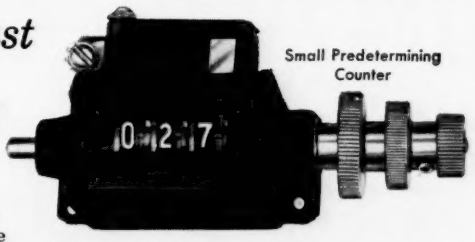
New Model 25 Linear Integrator is a ball and disc integrating mechanism, assembled with a counter and output pulse switch. Adapted to strip chart recorders of all types and sizes, and can be used whereever the variable to be integrated or averaged is presented as a shaft position or displacement. Because of the Low Torque Requirement, this unit can accept outputs of sensing elements directly, without the need of servos. Pulse output provides for convenient electrical transmission for use in data system or remote counter.—*Librascope, Inc.*, 808 *Western Ave., Glendale, Calif.*



For more information circle **240** on inquiry card.

Here's why it pays to CALL FOR HELP

...first thing instead of last



Small Predetermining Counter

If you want to do anything "by the numbers," first thing to do is call the No. 1 man . . . your Veeder-Root District Engineer. Because he's an *original thinker* like yourself when it comes to designing or building *Count*rol into any type of product or process.

He knows his book on the most complete line of standard electrical, mechanical and manual counters made anywhere in the world. And from this line he can very likely adapt or modify a standard counter to your special needs. This saves cost and time in engineering, purchasing, assembly.

And you get a lot of new user-benefits to merchandise . . . direct readings, rather than dials and scales . . . remote indication from plant to office if needed . . . production figures that serve as a fair base for wage and incentive payments, production and stock *Count*rol, tax computation . . . and as proof of your own performance guarantee. So call the V-R man in, *when you begin* . . . look him up in your local phone book, or write direct to:

VEEDER-ROOT INC., Hartford 2, Connecticut

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For more information circle **77** on inquiry card.

Nash Instrument Air Compressors deliver only clean air, free from oil or dust, and without filters

Here is Why!

You can dispense with oil filters and dust filters when you install ®Nash® Clean Air Compressors. You can save the cost of maintaining these devices. You can greatly reduce instrument maintenance costs. For the Nash employs no internal lubrication, therefore no troublesome oil is in the delivered air. Moreover, air from a Nash is thoroughly washed and cooled as it passes thru the pump. Dust in the plant atmosphere, even fly ash, is immediately removed.

®Nash® Clean Air Compressors are simple, with only one moving element. No valves, gears, pistons, sliding vanes, or other enemies of long life and constant performance complicate a Nash. No aftercoolers are needed. You will find it profitable to investigate these pumps, now.

No oil filters.
No dust filters.
No internal lubrication to contaminate air handled.
No internal wearing parts.
No valves, pistons, or vanes.
Non-pulsating pressure.
Original performance constant over a long pump life.
Low maintenance cost.

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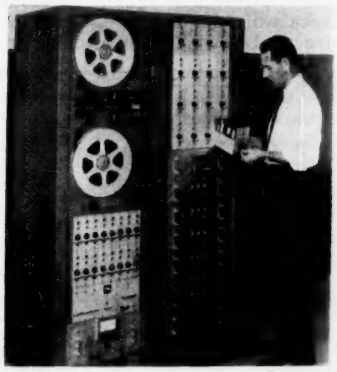
370 WILSON, SO. NORWALK, CONN.

RECORDATA SYSTEM

New series 3000 Multi-Channel Magnetic Tape Recording System featuring 300-kc bandwidth. Accom-



modates reel sizes up to 14" standard; can be ordered to 19" reels. Tape transports accommodate 1/4, 1/2, or 1 inch tape. Instant selection of Direct FM or PDM recording or playback in any combination.—*American Electronics, Inc., 655 W. Washington Blvd., Los Angeles 15, Calif.*

For more information circle **241** on inquiry card.

SIZE 11 RESOLVER

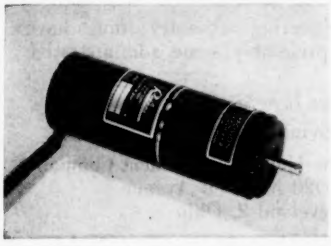
New high precision Size 11 Resolver is "ideal for incorporation in airborne or other miniaturized sys-

tems requiring high accuracy in a small package." Fully compensated units are provided for use in servo systems where highly accurate performance must be insured over a wide temperature range. Both compensated and uncompensated resolvers are available in a wide range of 400 to 1600-cycle models.—*Reeves Instrument Corp., 207 E. 91st St., New York 28, N. Y.*

For more information circle **242** on inquiry card.

RESOLVER-BOOSTER AMPLIFIER

New self-contained combination resolver-booster amplifier which completely eliminates external booster amplifiers, replaces components many



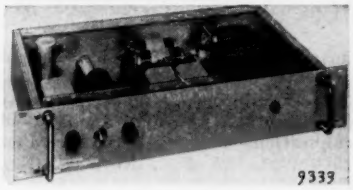
times its size without sacrificing accuracy of performance. Transformation ratio is carefully standardized at one to one with a maximum error of 0.1% and a phase shift of less than 3 minutes. Temperature compensation is such that there is less than ±0.05% variation for the entire temperature range of −55° to 80°C. A high input impedance of approximately 8 megohms eliminates loading effects.—*Reeves Instrument Corp., 207 East 91st St., New York 28, N. Y.*

For more information circle **243** on inquiry card.

POWER SUPPLIES

POWER MODULE

New universal power module supplies power and reference voltages for all modules of maker's new line of

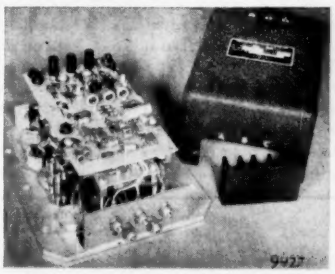


modular digital instruments. Besides modular construction, it features improved engineering; fully transistorized circuits; meets many applicable MIL specs; power consumption reduced and heat dissipation minimized. Input power can vary from 50 to 400 cps. Freedom from line transients and radio noise is provided by a new stepper drive design.—*Electro Instruments, Inc., 3794 Rosecrans, San Diego, Calif.*

For more information circle **244** on inquiry card.

TRANSISTORIZED INVERTER

New CW-1029 inverter is planned for use as power supply to servos of second stage rocket for Vanguard



Project; is said to be first transistorized device with power of 300 va; weights 5.5 lb; volume is 96 cu in. Requires no servicing during life estimated in excess of 10,000 hr. Controls 400 cps to ±0.2 cycles.—*Electrosolids Corp., 7436 Varna Ave., N. Hollywood, Calif.*

For more information circle **245** on inquiry card.

RACK-MOUNTED SUPPLIES

New Vari-Flex low-voltage regulated power supplies are relay rack mounted. All eight models have better

Do you think about angular acceleration?
CONVAIR
Division of General Dynamics Corporation
does...
and uses Statham Angular Accelerometers to test...
B-58 Hustler...the first supersonic bomber for the United States Air Force.
Statham liquid rotor angular accelerometers are rugged and reliable. They may be ordered with either an unbonded strain gage or inductive pickoff and are available in ranges from ±1.5 to ±3,000 rad/sec².
Please request our Accelerometer Catalog and Instrument Notes No. 26 "Some Design Considerations For Liquid Rotor Angular Accelerometers"
Statham
LABORATORIES
LOS ANGELES 64, CALIFORNIA

For more information circle **78** on inquiry card.

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Whether your optics needs are for small or large quantities, your inquiry will get prompt attention from the largest western producer of precision optics. Large optical glass stock assures quick delivery. An integrated engineering and research staff assists you in design and insures that the most advanced techniques are applied to your project.

LENSES:
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For more information circle **79** on inquiry card.

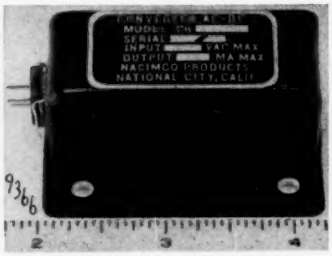
NEW INSTRUMENTS

than 0.2% line and load regulation.—*Hamner Electronics Co., Inc., P. O. Box 531, Princeton, N. J.*

For more information circle **246** on inquiry card.

AC-DC CONVERTER

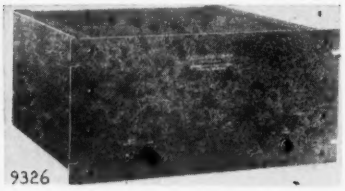
New 8-oz converter, qualified for missile environmental conditions, is for measuring, recording and telemetering applications; provides output of 0 to 12.5 vdc directly proportional to peak alternating input. Linearity is better than 1%; accuracy 0.1% of calibration.—*Nacimco Products, Inc., 2300 National Ave., National City, Calif.*



For more information circle **247** on inquiry card.

PROGRAMMED POWER SUPPLY

New Model 3-200 P can be automatically programmed by punched tape or any system which supplies binary-coded decimal signals. It supplies d-c voltages in 1-v steps from −300 v to +300 v at currents from 0 to 200 ma. Voltages are selected by applying pulses from 28-v source to 13 sealed plug-in type mercury-wetted or dry contact relays. Ten are used for voltage selection, two for polarity, one for reset.—*Dressen-Barnes Corp., 250 N. Vinedo Ave. Pasadena, Calif.*



For more information circle **248** on inquiry card.

TESTING, INSPECTION

TUBE THICKNESS GAGE

New automatic gaging machine checks wall and bottom thickness of impact-extruded aluminum tubing and automatically separates them into "good", "rectifiable" and "rejected" categories at the rate of 1000/hr.—*Pratt & Whitney Co. Inc., West Hartford 1, Conn.*

For more information circle **249** on inquiry card.

PINHOLE DETECTOR

New pinhole detector can detect 0.001" holes in opaque strip steel measuring 0.01" or less at strip speeds up to 2000 fpm; operates on dc to obviate risk of "dead bands" in strip and enhance sensitivity in detection of angular as well as vertical holes.—*General Electric Co., Specialty Control Dept., Waynesboro, Va.*

For more information circle **250** on inquiry card.

ENGINEERING MANAGER

Administrative responsibilities in the flow and pressure instrument field. We are seeking a man with at least 10 years engineering experience to direct the engineering activities and new instrument development work of our Instrument Division.

Degree in mechanical or electrical engineering necessary; must have working knowledge of electronics and preferably some administrative experience. Age preference 35-45.

Good salary plus profit sharing and other benefits.

Write to J. B. Meriam, Jr., President, giving full resume.

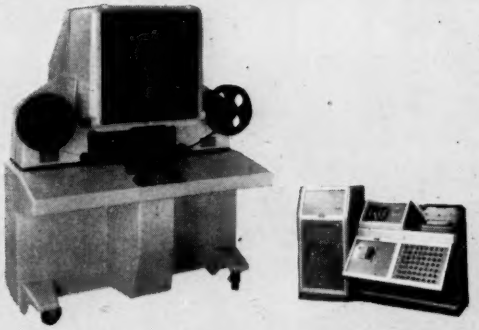
The Meriam Instrument Company
10920 Madison Avenue
Cleveland 2, Ohio

LOOK TO *Richardson Camera Co.*

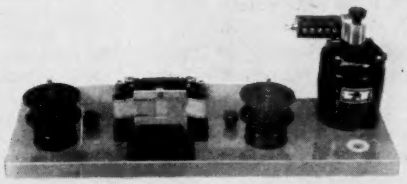
FOR DESIGN AND MANUFACTURE OF QUALITY DATA FILM EQUIPMENT

WE DESIGN AND MANUFACTURE THE PRECISION INSTRUMENTS WHICH ARE VITAL COMPONENTS OF OUR FILM VIEWERS AND DATA PROCESSING EQUIPMENT●

HERE ARE A FEW APPLICATIONS OF OUR MODEL T-400 INTERCHANGEABLE FILM TRANSPORT MECHANISM●



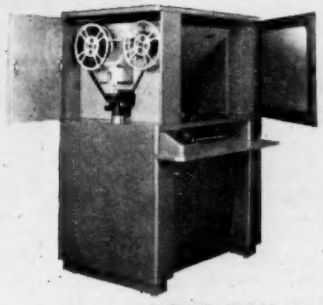
MODEL VF-500 FILM READER
SHOWN WITH ELECTRONIC ACCESSORY GROUP



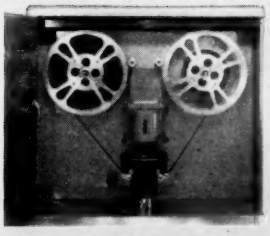
MODEL RKC-4002
FILM DRIVE
FOR USE ON OPTICAL CONTOUR COMPARATORS

MODEL T-400 INTERCHANGEABLE FILM TRANSPORT

SIZES: 8MM, 16MM, 35MM, 55MM, 65MM AND 70MM.
A PRECISION INSTRUMENT STANDARD ON ALL RICHARDSON FILM VIEWERS AND FILM READERS. ALSO ADAPTABLE TO DATA PROCESSING EQUIPMENT PRODUCED BY LEADING MANUFACTURERS●



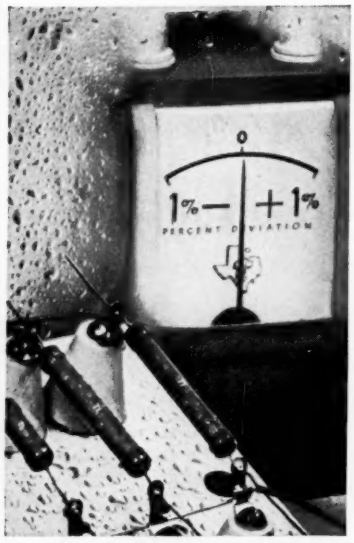
MODEL R-100
FILM VIEWER



MODEL R-4001 PROJECTOR PLATE

RICHARDSON CAMERA COMPANY • 171 WEST MAGNOLIA BOULEVARD • BURBANK • CALIFORNIA

For more information circle **80** on inquiry card.



TI MIL-Line Precision Resistors

HOLD TOLERANCE . . .

EVEN WHEN DRIPPING WET!

Soaking wet, dried out, or 'shook-up,' TI MIL-Line deposited carbon resistors still far exceed MIL-R 10509B. They emerge from one acceptance test after another—by major electronics manufacturers—with performance records that have not been equalled. *It's the seal that makes the difference* . . . an exclusive Texas Instruments process that snugly wraps these precision resistors in tough jackets of a special coating with high dielectric strength.

For ease in design, production, and maintenance . . . for improving the reliability and saleability of your products, the moisture resistance of TI deposited carbon MIL-Line resistors is just one field-proven factor. You also get a choice of 1, 2, or 5% tolerances . . . high stability over wide temperature ranges and under full load . . . low negative temperature coefficients . . . negligible voltage coefficient and noise levels . . . long shelf life . . . wide selection of sizes and resistance values . . . reasonable prices . . . and, if desired, reel-type packaging for automation.

Here is a typical TI reel pack designed to speed production. TI precision deposited carbon resistors are mass produced and packaged in five sizes from ½ watt to 2 watts with resistance values from 25 ohms to 30 megohms.

For complete data, write for Bulletin DL-C 539.

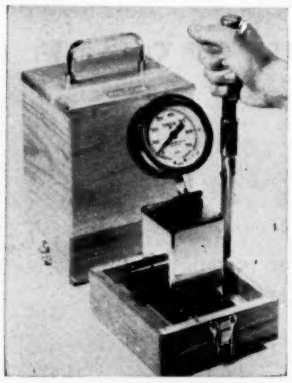
TEXAS INSTRUMENTS
INCORPORATED
6000 LEMMON AVENUE DALLAS 9, TEXAS

For more information circle **81** on inquiry card.

NEW INSTRUMENTS

TORQUE WRENCH CALIBRATOR

New hydraulic torque wrench calibrator is capable of testing torque wrenches to within 1% of accuracy.

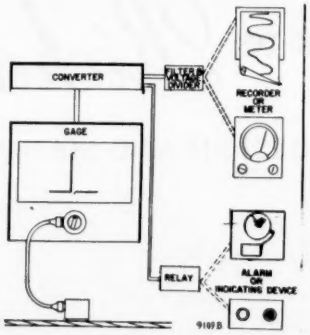


Unit is answer to the fabricators' need for low cost, portable testing device which enables the operator to correct quickly faulty micrometer settings on torque wrenches, and recalibrate other types of torque wrenches. No electrical outlets, air feeds, etc. are needed. Accurately measured by a specially calibrated hydraulic gage which makes readings directly in torque.—*Skidmore-Wilhelm Mfg. Co., 442 S. Green Rd., Cleveland 21, Ohio.*

For more information circle **251** on inquiry card.

THICKNESS RECORDER

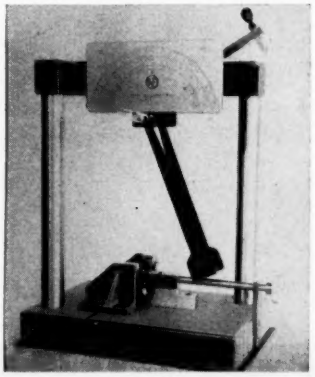
New gating and recording circuits for "Vidigage" ultrasonic thickness testers record thickness of metal or plastic and signal "high" and "low" with tolerances as close as 0.02% of standard thickness.—*Branson Instrument, Inc., 37 Brown House, Stamford, Conn.*



For more information circle **252** on inquiry card.

IMPACT TESTER

New machine makes Izod (cantilever beam) or Charpy (simple beam) test on each of three capacity ranges.



Separate hammer for each test in each capacity range (6 hammers in all). Hammers are interchangeable. Individual calibration of each hammer assures accuracy.—*Testing Machines Inc., 123 W. 64 St., New York 23, N. Y.*

For more information circle **253** on inquiry card.

TANK-O-METER

FOR MEASURING TANK CONTENTS ANY DISTANCE AWAY

TANK MAY BE BURIED, ELEVATED, OPEN, CLOSED, VENTED OR UNDER PRESSURE OR VACUUM

SEND FOR BULLETINS

Also gauges for:
Barometric Pressure (Mercury Column)
Absolute Pressure (Mercury Column)
Pressure and Vacuum
Differential Pressure
Inclined Manometers for draft, pressure or differential pressure.

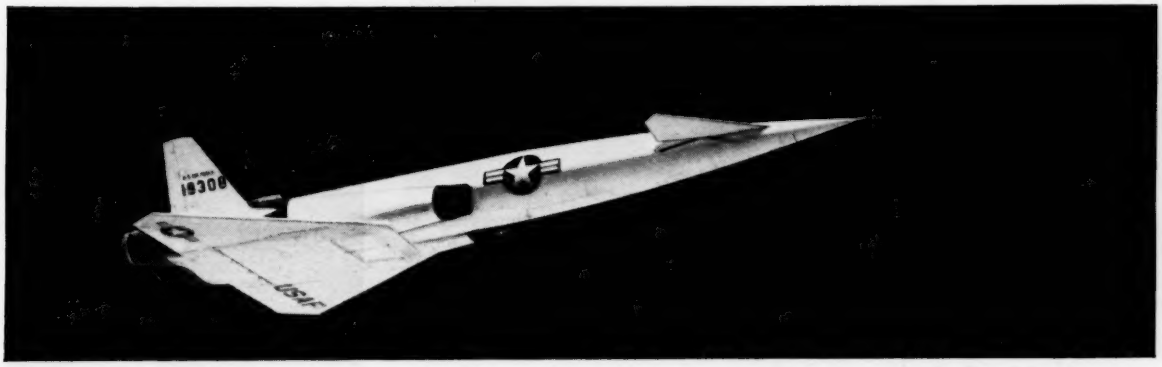
UEHLING INSTRUMENT CO. 470 GETTY AVE., PATERSON, N. J.

For more information circle **82** on inquiry card.

Engineers: This coupon means action!

Success of X-10 Test Missile program steps up systems engineering work on

Intercontinental SM-64 Navaho



The pace is quickening, as we gather forces for the climactic effort on the Navaho. If you like excitement in your engineering—this is it! You can decide now, and still get in on the work coming up at North American's Missile Development Division. It's going to be an assignment you'll be glad you took part in for years ahead.

James A. Trapp, 33, has been with NAA's Missile Division since 1952. He holds both BS and MS in Electrical Engineering. Now Group Leader, Auto Checkout Systems, he supervises development of digital techniques. Hi-fi fan and fisherman, this Oklahoman now lives in Long Beach with his wife and 2 California tots.

The Navaho is a project with the toughest kind of painstaking engineering behind it. It's been several years now since this organization set out to deliver to the Air Force a complete strategic weapon system. On the way we opened up and proved out more workable missile information than any other source: structures, guidance, propulsion, armament, ground handling, launching—the works. Now you can join us... get in at the forefront of missile technology. If you do, you're going to build a weapon with the world's most advanced self-contained guidance system ... driven at supersonic speeds by both rocket and ram-jet engines ... and packing an accuracy/payload punch that's unbeatable in the foreseeable future.

Charles H. ("Chuck") Lauritsen, 31-year old ex-Navy man, hails originally from Beatrice, Neb. Study at Chicago, Northwestern and Michigan gave him his BS and MS, Aero Eng. Starting in 1947, he rose thru Group Leader to Section Head of Project Aerodynamics, responsible for aerodynamic analysis on all Division contracts.

Join us now. All the things it takes to perfect a major intercontinental missile are available to you here. You can step up your own career ... grow in stature while working with some of the finest minds in the missile field... and advance your education, if you wish, with our Tuition Refund Plan.

MISSILE DEVELOPMENT DIVISION OF

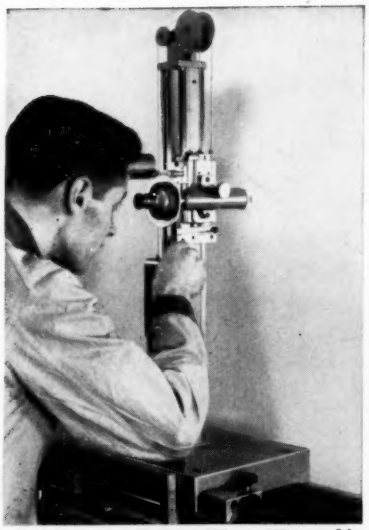
NORTH AMERICAN AVIATION, INC.

Mr. R. L. Cunningham, Engineering Personnel Manager, Dept. IA-7
12214 Lakewood Boulevard, Downey, Calif.
Dear Mr. Cunningham:
Please send me career information on Missile Development Division. I am interested in the following fields (check one or more).
Systems ☐ Guidance ☐ Structures ☐ Propulsion ☐ Armament ☐ Check Out ☐ Ground Handling ☐ Aerodynamics ☐ Thermodynamics ☐ Dynamics ☐

Name_____ Home Address_____

Degree(s)_____ Home Phone_____

Experience_____



M1238-1818 — *Range 18" x 18", working distance 9" to infinity. Reads to 0.001" up to 24" working distance. Protractor ocular reads to 3 minutes of arc. Image is erect.*

Cut inspection time in half

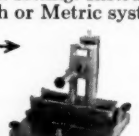
with new Gaertner Coordinate Cathetometers

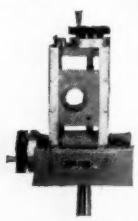
These convenient, reliable optical instruments permit making precise coordinate measurements in a vertical plane. The two dimensions are measured with one setting, object does not have to be rotated. Inspection time is cut in half and resetting errors eliminated.

Versatile Gaertner Coordinate Cathetometers are ideally suited for precision measurements on large objects; also objects or points in recessed, remote, or inaccessible locations. Applications include measuring jet engine sections, complicated castings, printed circuits, bolt holes and bosses on large piece parts, traces on cathode ray tubes, etc.

Because these are optical rather than mechanical measuring instruments, you make non-destructive measurements without contact, distortion, or concern about pressure being applied to the object when making a setting. Instruments available in English or Metric system.

M1236-46— Horizontal range 6", vertical range 4". Reads to 0.0001", working distance 5" to infinity.





M1236-22— Range 2" x 2", reads to 0.0001". Working distance 5" to infinity. Shown with 19 mm mounting rod, and without telemicroscope. Instrument permits precise coordinate movement of other objects such as photo cells, probes, etc., in place of telemicroscope.

Write for Bulletin 188-53

The Gaertner Scientific Corporation

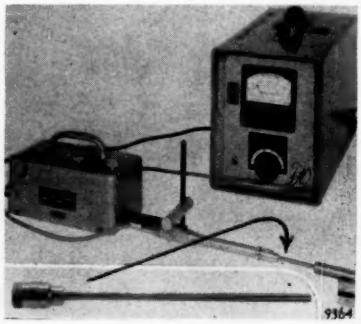
1211 Wrightwood Ave., Chicago 14, Ill.
Telephone: BUckingham 1-5335

For more information circle **83** on inquiry card.

NEW INSTRUMENTS

SURFACE FINISH TRACER

New Type LC tracer, added to "Profilometer" line of surface roughness measuring instruments, is designed for surface roughness measurements in ¼" dia holes to a depth of 6" (also available in longer or shorter lengths).—*Micrometrical Mfg. Co., 345 So. Main St., Ann Arbor, Mich.*



For more information circle **254** on inquiry card.

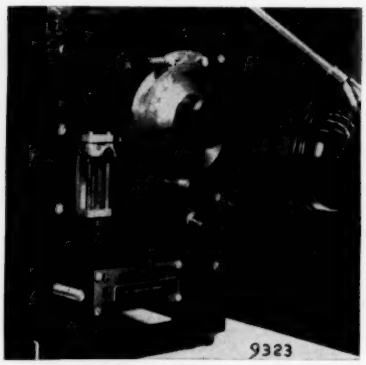
VARIANCE PHOTOMETER

New photoelectric photometer can detect light changes in microlumen range; operating sensitivity is adjustable over wide range. Can detect deviations from normal configuration of solids, liquids, and visible gases such as detecting flaws, counting and maintaining quality control in yarn production: For example, in a length of nylon yarn containing many filaments each measuring 0.00015", it is said to detect a minute break of one filament with equal accuracy at all times across any distance up to 25 ft.—*Lindly & Co., Mineola, N. Y.*

For more information circle **255** on inquiry card.

FIBER VIBRASCOPE

New Model A.1 Fiber Vibrascope measures single-fiber or strand linear density (denier) by vibrating the variably-weighted fiber at a preselected length at constant frequency. Operator can obtain linear density on direct-reading linear dial in less than one minute. Range is about 1 to 100 denier (about 0.000001 to 0.0001 gr/cm) with correspondingly small diameters determined by specimen volume density. Model A.2 is available for deniers to about 1600.—*G. F. Bush Assoc., Box 175, Princeton, N. J.*



For more information circle **256** on inquiry card.

VALVES, ACTUATORS

TORQUE BOOSTER

New Type 141F12 rotary torque booster for turbojet engine control offers failure-proof hydraulic amplification at 8-to-1 ratio. Reliability is attained by unique dirt-insensitive servo-valve construction with complete protection against torque feedback to

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Balzers means research in high vacuum process

For more information circle **84** on inquiry card.

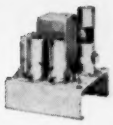
FREQUENCY STANDARDS

*3⅛" high
400 - 1000 cy.

PRECISION FORK UNIT
TYPE 50

Size 1" dia. x 3¾" H. Wght., 4 oz.*
Frequencies: 240 to 1000 cycles
Accuracies:—
Type 50 (±.02% at —65° to 85°C)
Type R50 (±.002% at 15° to 35°C)
Double triode and 5 pigtail parts required
Input, Tube heater voltage and B voltage
Output, approx. 5V into 200,000 ohms

FREQUENCY STANDARD
TYPE 50L



Size 3¾" x 4½" x 5½" High
Weight, 2 lbs.
Frequencies: 50, 60, 75 or 100 cycles
Accuracies:—
Type 50L (±.02% at —65° to 85°C)
Type R50L (±.002% at 15° to 35°C)
Output, 3V into 200,000 ohms
Input, 150 to 300V, B (6V at .6 amps.)

*3½" high
400 to 500 cy.
optional

PRECISION FORK UNIT
TYPE 2003

Size 1½" dia. x 4½" H. Wght. 8 oz.*
Frequencies: 200 to 4000 cycles
Accuracies:—
Type 2003 (±.02% at —65° to 85°C)
Type R2003 (±.002% at 15° to 35°C)
Type W2003 (±.005% at —65° to 85°C)
Double triode and 5 pigtail parts required
Input and output same as Type 50, above

FREQUENCY STANDARD
TYPE 2005

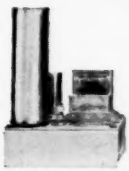
Size, 8" x 8" x 7¼" High
Weight, 14 lbs.
Frequencies: 50 to 400 cycles
(Specify)
Accuracy: ±.001% from 20° to 30°C
Output, 10 Watts at 115 Volts
Input, 115V. (50 to 400 cycles)

FREQUENCY STANDARD
TYPE 2007T
TRANSISTORIZED

Size 1½" dia. x 4½" H. Wght. 7 ozs.*
Frequencies: 240 to 1000 cycles
Accuracies:—Same as 2003, above
Type 2007S—Silicon type
Input, 28V.
Output, Multitap, 75 to 100,000 ohms
*3½" in 2007S, 400 to 800 cycles.

FREQUENCY STANDARD
TYPE 2121A

Size
8¾" x 19" panel
Weight, 25 lbs.
Output: 115V
60 cycles, 10 Watt
Accuracy:
±.001% from 20° to 30°C
Input, 115V (50 to 400 cycles)

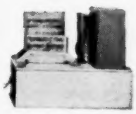


FREQUENCY STANDARD
TYPE 2001-2

Size 3¾" x 4½" x 6" H., Wght. 26 oz.
Frequencies: 200 to 3000 cycles
Accuracy: ±.001% at 20° to 30°C
Output: 5V. at 250,000 ohms
Input: Heater voltage, 6.3 - 12 - 28
B voltage, 100 to 300 V., at 5 to 10 ma.

FREQUENCY STANDARD
TYPE 2111C

Size, with cover
10" x 17" x 9" H.
Panel model
10" x 19" x 8¾" H.
Weight, 25 lbs.
Frequencies: 50 to 1000 cycles
Accuracy: (±.002% at 15° to 35°C)
Output: 115V, 75W. Input: 115V, 50 to 75 cycles.



ACCESSORY UNITS
for TYPE 2001-2

L—For low frequencies
multi-vibrator type, 40-200 cy.
D—For low frequencies
counter type, 40-200 cy.
H—For high freqs, up to 20 KC.
M—Power Amplifier, 2W output.
P—Power supply.

This organization makes frequency standards within a range of 30 to 30,000 cycles. They are used extensively by aviation, industry, government departments, armed forces—where maximum accuracy and durability are required.

WHEN REQUESTING INFORMATION PLEASE SPECIFY TYPE NUMBER

American Time Products, Inc.

580 FIFTH AVENUE, NEW YORK 36, N. Y.

For more information circle **85** on inquiry card.

how many ?

INSTRUMENT makers are using more and more Johnson pivots. Maybe you're one of them and can tell how many Johnson pivots are held in the teaspoon above.

There's a prize! No world beater, but a handy transistor portable radio to the closest guesser. In case of ties, earliest postmark will qualify.

But you needn't guess when you need precision pivots, accurately machined, scientifically hardened and polished to a metallographic finish. Direct your inquiry to Johnson for satisfaction.

Mail your estimate of the number of pivots in this regular teaspoon now to qualify for the prize. A postcard will do.

Welton V. Johnson
Engineering Company, Inc.

precision miniature parts

95 SUMMIT AVENUE

SUMMIT 6, NEW JERSEY

For more information circle **86** on inquiry card.

NEW INSTRUMENTS

input. In case of hydraulic power failure, a direct mechanical link permits no-boost operation. Input overloads of 600 inch-pounds do not damage unit.—*Manning, Maxwell & Moore, Inc., Aircraft Products Div., Danbury, Conn.*

For more information circle **257** on inquiry card.

MIDGET SOLENOID VALVE

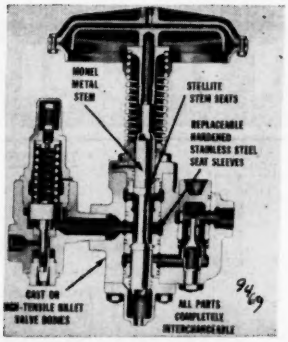
New K-27H 3⅛"-high solenoid valve is suitable for all common industrial fluids at operating pressures

up to 130 psi. Available in ⅛" ips, normally closed, valve features spring-loaded plunger with soft seat for bubble-tight shutoff, brass bar-stock body, two-wire continuous-duty solenoid, and operates in any position.—*General Controls Co.*, 801 *Allen Ave., Glendale* 1, *Calif.*

For more information circle **258** on inquiry card.

H-P VALVES

New line of diaphragm-operated high-pressure control valves is for use in oil, air, steam, and water service at pressures up to 6000 psi. Resistance to corrosion is assured by the Monel

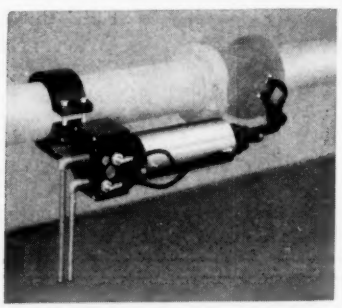


metal valve stem, hardened stainless steel seat sleeves, and valve bodies of cast Navy M bronze or hi-tensile alloy billet bronze. Stellite seats are electro-bonded to the Monel stem and stainless steel seat sleeves are easily replaceable.—*Sinclair-Collins Valve Co.*, 454 *Morgan Ave., Akron* 11, *Ohio.*

For more information circle **259** on inquiry card.

PLUG-VALVE ACTUATORS

New actuators for automatic operation of plug valves in existing installations or new projects, feature



positive complete closing and opening; are packaged assemblies delivered ready to attach to pipe and plug valve stem in minutes without special tools. Available in 1" to 8" pipe sizes and fit all popular makes of plug valves. (10" to 12" size will soon be available.)—*Pantex Mfg. Corp., P. O. Box* 660, *Pawtucket, R. I.*

For more information circle **260** on inquiry card.

INSTRUMENT TECHNICIANS

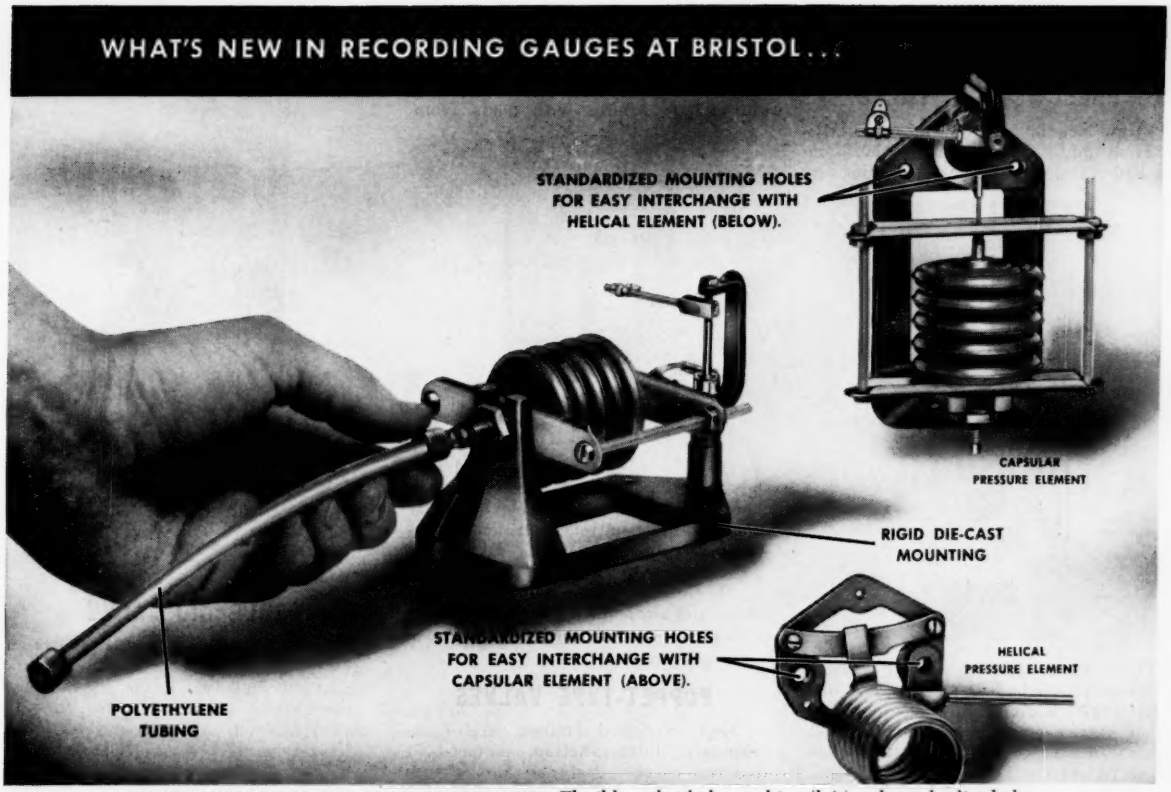
Pittsburgh Consolidation Coal Company is now entering the process industries. This calls for further expansion of our technical service activity in the general field of coal conversion, coal tar refining and chemical production.

We welcome replies from instrument mechanics with 5-10 years experience in electronic and pneumatic instrumentation.

These positions offer the opportunity to participate in the growth and expansion of this large company into the process industries. Newly commercialized projects include long distance coal pipeline and multi-million dollar chemical plant in Newark, New Jersey. Other projects include continuous coal carbonization, complete refining of coal tar oils, gas synthesis, etc.

Please address replies, including education, experience, references and salary desired to:

William F. Saalbach, Personnel & Office Supervisor, Research and Development Division, Pittsburgh Consolidation Coal Co., Library, Pa. (13 miles south of downtown Pittsburgh)


WHAT'S NEW IN RECORDING GAUGES AT BRISTOL...
STANDARDIZED MOUNTING HOLES FOR EASY INTERCHANGE WITH HELICAL ELEMENT (BELOW).
CAPSULAR PRESSURE ELEMENT
RIGID DIE-CAST MOUNTING
STANDARDIZED MOUNTING HOLES FOR EASY INTERCHANGE WITH CAPSULAR ELEMENT (ABOVE).
HELICAL PRESSURE ELEMENT
POLYETHYLENE TUBING

RECENT BRISTOL RECORDING GAUGE DEVELOPMENTS. Flexible polyethylene tubing *(left)* and standardized element mountings simplify element interchange, provide increased mounting rigidity and vibration isolation.

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A key reason for this preference: *Bristol Pressure Measuring Elements.* They're the result of more than 68 years of practical experience. *And field reports show that our recording gauges, equipped with these famed measuring elements have been in constant service for up to 40 years! An outstanding record for long life and stability!*

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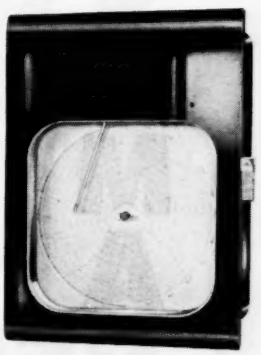
Easy-change elements. Element mountings have been redesigned to insure interchangeability of elements. You can buy a pressure gauge with any standard helical element and change later to any standard capsular type element, or *vice versa.*

Extra mounting rigidity. Rigid cast-aluminum element mounting assures greater accuracy, stability and reliability.

Flexible polyethylene tubing used to connect measuring elements. Simplifies interchange of elements, simplifies maintenance. Isolates element from shock and vibration.

Improved element materials. Capsular measuring elements are now available in stainless steel and Ni-Span C, as well as phosphor bronze. As a result, this type of measuring element, ideal for low pressures, can now be used for a large number of corrosive fluids. Helical elements are now available in Ni-Span C, too.

Find out more about these latest Bristol gauges for recording, automatic control, pneumatic transmission and telemetering. Send for our 32-page catalog G621, today. The Bristol Company, 113 Bristol Road, Waterbury 20, Conn. 6.87



BIG REASON FOR USER PREFERENCE is Bristol measuring elements, unexcelled for accuracy, precision, long-term stability. **They're made in ranges from 0-6mm mercury absolute to 0-10,000 psi.**

BRISTOL *TRAIL-BLAZERS IN PROCESS AUTOMATION*

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

For more information circle **87** on inquiry card.

NEW INSTRUMENTS

BELLOWS-SEAL VALVE

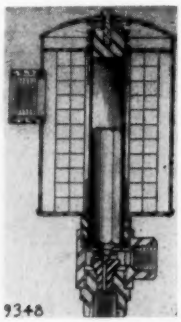
New No. 800 bellows construction is 321 stainless steel totally enclosed in a 316 stainless steel barstock housing.

Three types of bellows for various pressures up to 850 psi are available in single, double, and three-ply. Teflon V-ring packing is used with bellows in case of bellows failure. Flow coefficient Cv 0.0001 to Cv 6.5.—*Uniflow Valve Corp.*, 19 *Quine St., Cranford, N. J.*

For more information circle **261** on inquiry card.

STAINLESS SOLENOID VALVES

New Type GX "All 316" stainless steel valves are available in ⅛" ¼" and ⅜" pipe sizes with ports from



$\frac{1}{16}$" to ¼". Only 316 stainless and Teflon contact fluid. Valves maintain "packless" feature; are normally closed, angle pattern with coils unconditionally guaranteed. Explosion-proof housings can be furnished.—*J. D. Gould Co.*, 4707 *Massachusetts Ave., Indianapolis* 18, *Ind.*

For more information circle **262** on inquiry card.

POPPET-TYPE VALVES

New Hi-Speed Inlines, high-flow-capacity, instant-action, poppet-type control valves, designed for use on large brakes, clutches, etc., especially for high-speed applications, feature extremely short poppet travel for fast response. Valves are available with integral pilots or for remote pilot operation, in both 2 and 3-way types,

N-O or N-C. Working pressures from 10 to 200 psi; 1", 1¼" and 1½" NPT sizes.—*Valvair Corp.*, 454 *Morgan Ave., Akron* 11, *Ohio.*

For more information circle **263** on inquiry card.

SOLENOID VALVE

New 3-way double solenoid valve is available in three assemblies: (1) for *mixing* it has two inlets and a common outlet; (2) for *divided flow* it has one inlet and two outlets; and (3) for *cylinder control* it has an inlet, cylinder and exhaust connections with an optional check valve in case pressure source fails. Can be used at pressures from 5 to 1000 psi with both

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Here G. D. Schott (right), Flight Controls Department head, discusses computer solutions of control and guidance problems with E. V. Stearns (center), Inertial Guidance Department head, and J. E. Sherman, Analog Computer Section head.

MISSILE FLIGHT CONTROLS

— the creative field for engineers

Few fields equal missile systems flight controls in the need for original thinking. The ever-increasing performance of missiles presents problems that grow constantly in complexity. At Lockheed, weapon systems programs demand important advances in flight controls. Emphasis is on new ideas, new techniques.

Positions are open on the Sunnyvale, Palo Alto and Van Nuys staffs for engineers possessing strong ability and interest in: Research and development of advanced flight control systems for controlling missiles and rockets; system synthesis by application of control system feedback techniques; analysis and design of nonlinear servo systems; development of transistor and magnetic amplifier techniques in the design of advanced flight control systems; analysis and simulation of the dynamic performance of the guidance – autopilot – airframe combination; development of systems utilizing advanced types of inertial and gyroscopic instruments; analysis and design of hydraulic servo systems for controlling missiles at high Mach numbers; environmental and functional testing of prototype flight control systems.

Inquiries are invited from engineers possessing a high order of ability. Address the Research and Development Staff, Palo Alto 1, California.

Lockheed

MISSILE SYSTEMS DIVISION

LOCKHEED AIRCRAFT CORPORATION

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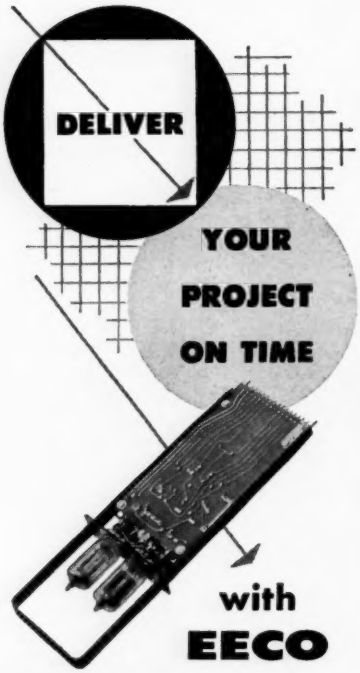

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PLUG-INS

Originally developed for EECO custom systems and proven in critical use, new EECO Computer-Series Plug-ins represent a refinement of the building-block concept to a degree hitherto unknown. Each of the full line of reliable, tested, and proven circuits is a complete off-the-shelf packaged function, performance-engineered for application where ultra-conservative design at the component level is essential because of system complexity.

New EECO Computer-Series Plug-ins enable you to meet your project delivery schedules by reducing systems-development time to a bare minimum and practically eliminating drafting and layout time. Your engineers can concentrate on system design instead of routine circuit detail. Your technicians can cut fabrication time and step up production by performing simple point-to-point wiring instead of wiring complex circuits. And system prototypes can generally be built directly without need for the "breadboard" stage.

Detailed information on new EECO Computer-Series Plug-ins and compatible equipment, as well as on other EECO products, is available in Catalog No. 856-A. Write for your copy—today.

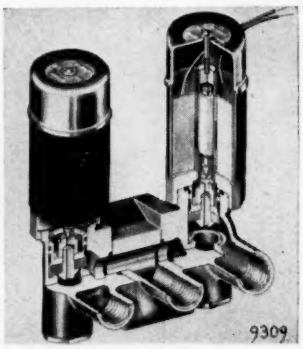
ELECTRONIC ENGINEERS AND PHYSICISTS —EECO offers immediate opportunities for qualified engineers in the transistor, amplifier, data-handling, pulse, timing, and systems-design fields. Send a resume of your qualifications to R. F. Lander, Dept. CS-2.

ENGINEERED ELECTRONICS COMPANY
(formerly EECO Production Company)
a subsidiary of
Electronic Engineering Company of California
506 EAST FIRST STREET
SANTA ANA, CALIFORNIA

For more information circle **89** on inquiry card.

NEW INSTRUMENTS

pistons normally closed and at 5 to 500 psi with either or both pistons



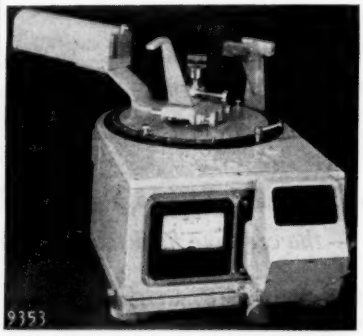
normally open. Available in ½" and ¾" pipe sizes.—*Atkomatic Valve Co., Inc., 545 W. Abbott St., Indianapolis 25, Ind.*

For more information circle **264** on inquiry card.

LABORATORY, ANALYTICAL

X-RAY GONIOMETER

Newly available in US is Hilger & Watts Ltd., Model Y-130, high-precision quartz-crystal x-ray gonio-



meter permitting unskilled operators to orinentate crystal surface and lattice planes quickly to within 30 seconds of arc. Features include: Large direct-reading scale; simple controls; higher sensitivity than required for even weakest quartz reflections; suitability for routine testing of both large and small crystal blanks. Can be used with either a high-intensity microfocus x-ray unit or with conventional x-ray diffraction equipment.—*Jarrell-Ash Co., 26 Farwell St., Newtonville 60, Mass.*

For more information circle **265** on inquiry card.

METAL CRYSTALS

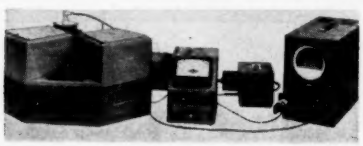
New metal single crystals and polycrystals are available in various metals (aluminum, tin, copper, etc.),

sizes, and quantities, and with broad range of metal purity, crystal orientation, and overall size. Surface may be as-grown, etched, or electropolished.—*Flow Corp., 85 Mystic St., Arlington, Mass.*

For more information circle **266** on inquiry card.

SPECTROPHOTOFLUOROMETER

New analytical instrument provides the advantages of spectrophotometry and sensitivity of fluorescence



measurement. Provides ready means for surveying new compounds by fluorescent measurement and for determination of environmental effects upon the intensity and position of fluorescent bands. Entire range of 200-800 millimicrons is covered by an activating and fluorescent monochromator; only 1 ml. of sample required. —*American Instrument Co., Inc., Silver Spring, Md.*

For more information circle **267** on inquiry card.

MAGNETS

HIGH ENERGY PRECISION ALNICO PERMANENT MAGNETS

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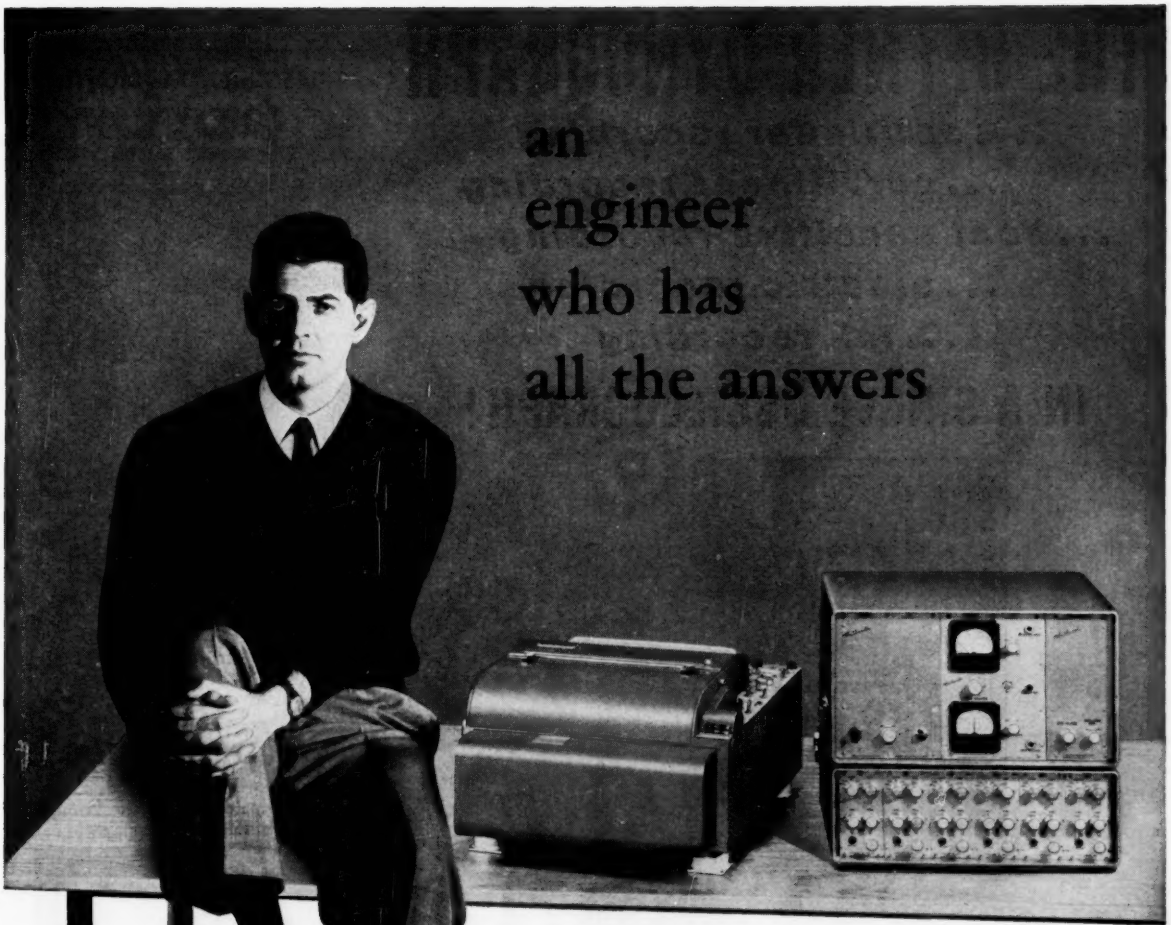
For more information circle **90** on inquiry card.



This engineer is fully equipped, with his Heiland Dynamic Recording System, to record a complete range of phenomena . . . strain, vibration, pressure, acceleration, temperature, impact and many others.

The 700-C Series Recording Oscillographs can put up to 60 traces on 12" wide recording paper at speeds from .03 to 144 in. per sec., with frequency response from DC to 3,000 cycles per second. Power supply is 28 volts DC or 115 volts AC. Both the oscillograph and the amplifier system (either carrier or linear/integrate) may be bench, shock, or vibration mounted, or installed in a standard relay rack without modification.

Whether your measuring and recording needs are for dynamic testing of guided missiles or aircraft; structural tests of buildings, bridges or ships; performance tests of heavy machinery or electrical equipment; riding quality evaluation of automobiles, trucks, or railroad coaches; physiological or medical research; or similar applications in all fields of industry, science and engineering—it will pay you to let a Honeywell Industrial Engineer show you why the Heiland System is unmatched for sensitivity, stability, and dependable performance. Call your nearest Minneapolis-Honeywell Industrial Sales Office today . . . *and* write for Bulletins 101-A and **107-A.**

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For more information circle **91** on inquiry card.

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For more information circle **92** on inquiry card.

NEW INSTRUMENTS

GAS CHROMATOGRAPH

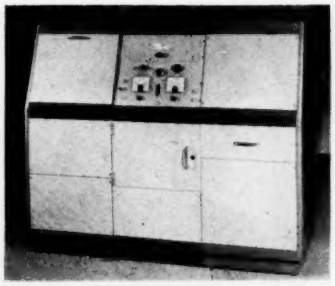
New GC-2 analyzes gases and liquids with boiling points up to 350°C; adapts fundamental principle

of gas chromatography, by using a tubular column packed with a material that separates components by passing them through column at different rates. Carrier gases, used to move sample through the column, include H, He, N, CO_2 or A.—*Beckman Instruments, Inc., Scientific Instruments Div., Fullerton, Calif.*

For more information circle **268** on inquiry card.

MASS SPECTROMETERS

New Time-of-Flight Mass Spectrometers operate on the time-of-flight principle of mass separation and



feature fast response time simplicity, and greater resolving power than available in non-magnetic instruments. Model 12-101 is especially designed for molecular beam work.—*Bendix Aviation Corp., Research Labs. Div., P. O. Box* 5115, *Detroit* 35, *Michigan.*

For more information circle **269** on inquiry card.

OPTICS

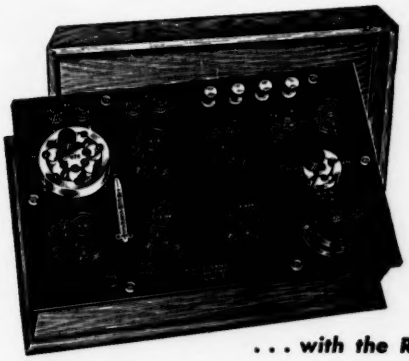
PLASTIC LENSES

New materials and methods have made plastic lenses more suitable for Fresnel, spherical and aspherical lenses, lenticular screens and prismatic shapes. Materials have: transmission reaching into both ends of the spectrum; uniform refractive index from batch to batch; high impact strength and light weight; easy fabrication; simple mounting; practically no limit to size.—*Optics Mfg. Corp., Industrial Div., Phila.* 34, *Pa.*

For more information circle **270** on inquiry card.

Precise

TEMPERATURE MEASUREMENTS



. . . with the Rubicon

MUELLER BRIDGE

A highly accurate and specialized form of the Wheatstone bridge designed expressly for precise resistance thermometry with three- or four-lead thermometers and for the measurement of other similar resistors within its range.

- Wide range: 0 to 141.1110 ohms in increments of 0.0001 ohm
- Unity ratio with provision for convenient checking and precise adjustment of ratio arms
- Built-in mercury commutator for lead resistance compensation
- Sub-panel switch construction
- Built-in plug and block assembly for conveniently checking ratio, bridge zero and thermometer resistance with no disturbance of external bridge connections

Described in Bulletin 100

. . . with the Rubicon

PORTABLE PRECISION POTENTIOMETER

A two-dial instrument of exceptional accuracy and sensitivity.

- High-sensitivity, sturdy, built-in Pointerlite galvanometer —permits balancing to within 2 microvolts in low resistance circuits
- Completely self-contained assembly—no external accessories except the thermocouple circuit
- Two ranges —0 to 16.1 and 0 to 161 millivolts—readable to within 2 and 20 microvolts respectively
- Sturdy, compact construction for long dependable service

Described in Bulletin 270

RUBICON COMPANY

Electrical Instrument Makers

3755 Ridge Avenue Philadelphia 32, Pa.

For more information circle **93** on inquiry card.

PANEL SPACE LIMITED? SPECIFY

DIALCO® 2-Terminal

Sub-Miniature Pilot Lights

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RUGGED

OMNIDIRECTIONAL PLASTIC DOMES

COMPLETELY INSULATED

Also available with "Taper-Tab" quick-connect terminals

BACK of panel insertion

or **FRONT** of panel insertion

△ Dimming and ◁ Non-dimming types

Also

1-Terminal Pilot Lights

for use on grounded circuits. Available with *binding screw* or *soldering* terminal.

DIALCO's expanded line of sub-miniature lights conform to all applicable Mil Specs. Use T-1¾ midget incandescent lamps—1.3 to 28 V. Spring mounted *Lens-with-Message* is readily positioned *after* installation . . . Mount from *back* of panel in 15/32" clearance hole; or from *front* of panel in 17/32" hole . . . 7 lens colors . . . Shown approx. actual size (top to bottom): No. 134-3830-375-6 . . . No. 101-3830-951 . . . No. 101-5030-951 . . . No. 109-3830-111 . . . No. 111-3830-111 . . . No. 107-1930-951.

Complete details in Brochures L-156 A and L-157.

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For more information circle **94** on inquiry card.

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For more information circle **95** on inquiry card.

NEW INSTRUMENTS

STROBOSCOPE

New miniaturized, high-intensity, white-light stroboscope features flash duration of 10 microseconds; light out-

put 5 lumen-seconds per flash; repetition rate 0 to 100 pulses per second; dimensions, 6" wide, 5" high, 5-¾" deep.—*Western Gear Corp., P. O. Box 182, Lynwood, Calif.*

For more information circle **271** on inquiry card.

FRESNEL LENS

New clear plastic Fresnel Lens permits solar furnaces to develop temperatures from 2,000° to 4,000° F.

Lenses are 14½" dia x 14" focal length.—*Edmund Scientific Co., Barrington, N. J.*

For more information circle **272** on inquiry card.

IRIS AND TARGET CONTROL

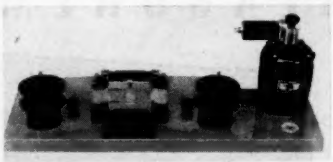
New automatic iris and target control unit for maker's industrial and institutional television systems auto-

matically compensates for variations in light up to 16,000 to 1; assures lowest possible aperture for maximum resolution, depth of field and contrast; obviates need for a variable-density filter and resulting shading.—*General Precision Lab., Inc., Pleasantville, N. Y.*

For more information circle **273** on inquiry card.

FILM DRIVE ASSEMBLY

New Model RKC-4002 is designed to mount on work table of an Eastman Contour Projector; accepts



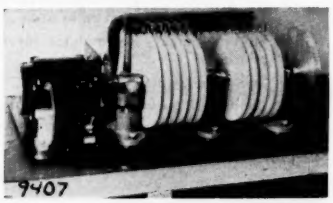
standard interchangeable Film Transport Mechanisms Model T-400 from 8 mm to 70 mm. Remote control panel permits operation in stop-motion, single frame advance and cine-motion at variable speeds either forward or reverse.—*Richardson Camera Co., 171 W. Magnolia Blvd., Burbank, Calif.*

For more information circle **274** on inquiry card.

SPEED, TIME, COUNT

MULTI-CIRCUIT SEQUENCER

New 10-circuit sequence programmer, incorporating 6" dia adjustable nylon cams, provides auto-

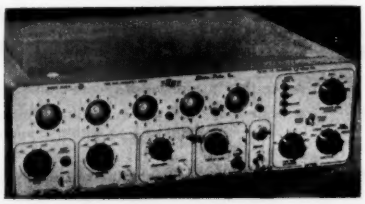


matic testing for capacitors and other apparatus requiring production inspection. Complete cycle is generated by cam shaft in 6 sec and settings of the cams can be changed quickly.—*Automatic Temperature Control Co., 5200 Pulaski Ave., Phila. 44, Pa.*

For more information circle **275** on inquiry card.

ELECTRONIC COUNTER

New Model 755OB frequency, period and time interval timer features modular construction, printed wiring.



It has one glow transfer counting tube per decade for both counting and indication; 200-mv input sensitivity; self-test function switch for checking internal time base, counter decades and measuring capacities from 100-cps to 100 kc and 10 μsec to 1.2 days. Counter tube life expectancy is over 10,000 hr.—*Electro-Pulse, Inc., 11861 Teale St., Culver City, Calif.*

For more information circle **276** on inquiry card.

IMMEDIATE DELIVERY

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"Stocked for Immediate Delivery"—can be music to the ears of your production design engineers or purchasing agent.

Out of thousands of styles and sizes of fine-silver headed rivets as specified in customer orders came a list of 70 standard size contacts most frequently used. All 70 *standards* are "Stocked for Immediate Delivery" at Mallory.

For your new designs . . . check the Mallory "preferred list" for a size to fit your job. A Mallory standard can save engineering time . . . assure economical cost and prompt delivery when you go into production.

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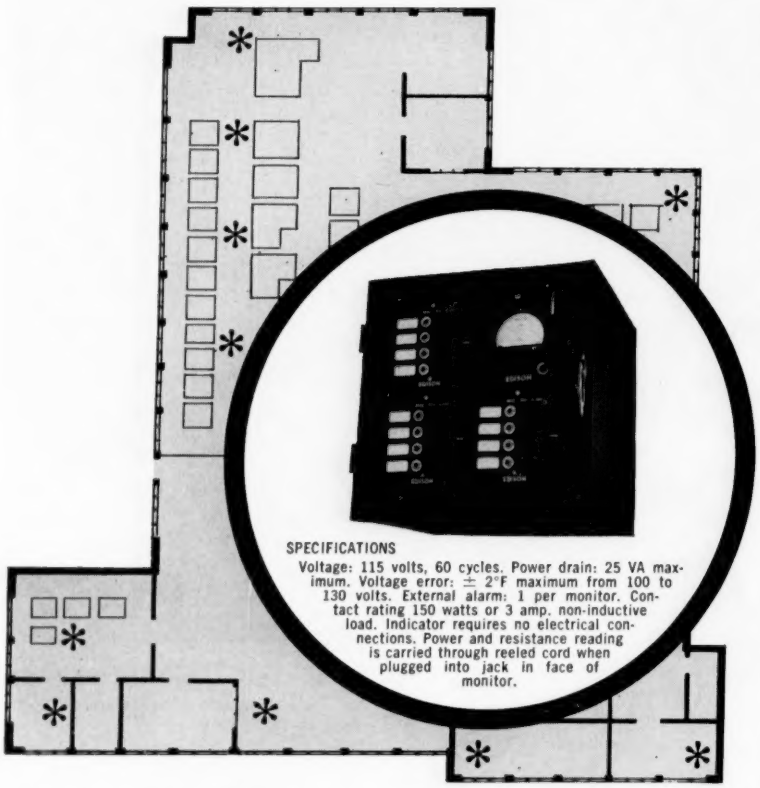
For more information circle **96** on inquiry card.

EDISON'S OMNIGUARD MONITORS CRITICAL* TEMPERATURES IN YOUR PLANT



SPECIFICATIONS

Voltage: 115 volts, 60 cycles. Power drain: 25 VA maximum. Voltage error: ± 2°F maximum from 100 to 130 volts. External alarm: 1 per monitor. Contact rating 150 watts or 3 amp. non-inductive load. Indicator requires no electrical connections. Power and resistance reading is carried through reeled cord when plugged into jack in face of monitor.

- VERSATILE — NEW CONCEPT OF ZONE MONITORING ALLOWS YOU TO PUT MONITOR UNITS WHERE YOU NEED THEM
- EFFICIENT — WARNS YOU BEFORE TROUBLE STARTS
- DEPENDABLE — NO MOVING PARTS ELIMINATE WEAR
- ECONOMICAL — COSTS LESS THAN ANY OTHER TEMPERATURE MONITORING SYSTEM YOU BUY MODULAR UNITS ONLY AS NEEDED

As few as four, and as many as several hundred critical temperature spots can be monitored at one central control panel or from local zone panels in your plant . . . with Edison's OMNIGUARD. Hot bearings, or excessive temperatures in oil lines, air ducts, and chemical processes can be visually checked at any time at any spot in your plant.

Here's how OMNIGUARD can save you a lot of money with a minimum of effort: just as soon as a critical temperature occurs at a point anywhere in your plant, the mechanism is automatically shut off, a warning bell rings and a lamp flashes on the monitor panel. Instantly the trouble source is pin-pointed, checked, and remedied . . . well in advance of otherwise costly trouble.

This entire Edison monitoring system uses no moving parts, except for the alarm relay contacts. No electronic tubes or expensive wiring between components is necessary. The actual detection is done with Edison Resistance Temperature Detectors, which signal the warning to OMNIGUARD.

Edison's Omniguard brochure, #3036A, gives the entire story on temperature monitoring. Write for it.

McGRAW EDISON

Thomas A. Edison
INDUSTRIES
INSTRUMENT DIVISION
WEST ORANGE, NEW JERSEY

For more information circle **97** on inquiry card.

NEW INSTRUMENTS

PROGRAMMING TIME SWITCH

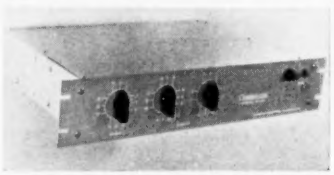
New 24-hr multiple-operation time switch provides automatic control of intermittently-operated equipment;

will handle as many as 48 on and 48 off operations in one day. Dial is scaled in 15-min graduations; can repeat entire schedule day after day. Calendar cutout device to make switch selective for all seven days of week is available as an accessory. Switch is sp-dt, rating 1000 w on 60-cps ac. —*Zenith Electric Co., Dept. IAP,* 152 *W. Walton St., Chicago* 10, *Ill.*

For more information circle **277** on inquiry card.

DIGITAL CLOCK

New Chrono-log digital clock is a compact, multiple output unit designed to serve as a time source for

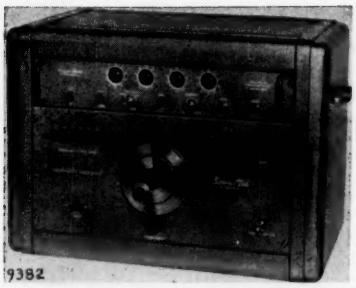


data loggers, data handling systems, computers, digital time displays and other applications where digital representation of time is required. Chrono-Log digital clock functions as a 24-hour program controller, providing a unique contact closure for every minute of the day. As many as three completely independent parallel outputs can be supplied in one unit. Digital clock is a compact, self-contained unit requiring only 3½" of panel height.—*Chrono-Log Corp., Dept. IA, P. O. Box* 4587, *Phila.* 31, *Pa.*

For more information circle **278** on inquiry card.

TACHOMETER CALIBRATOR

New Model ST-901 electronic decade type counter is combined with maker's precision electronic adjustable-speed drive. Tachometer under test is driven at a speed (usually from 0 to 500 rpm) infinitely adjustable by means of a 10-turn resistor. For rapid production testing, a push-button switch will select any one of five predetermined test speeds. Driving speed is continuously displayed with an ac-

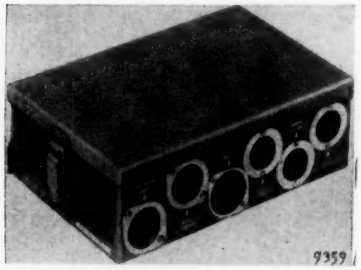


curacy of 1 rpm plus line frequency error. Counting speeds up to 50,000 counts per second are possible. Electronic pickup permits checking rotational or lineal speed of various motors, gear trains, etc.—*Servo-Tek Products Co.*, 1086 *Goffle Road, Hawthorne, N. J.*

For more information circle **279** on inquiry card.

ELECTRONIC TIMER

New electronic timer is said to have a repeat ability better than 0.01 sec. and reset time less than 0.01 sec. Ac-

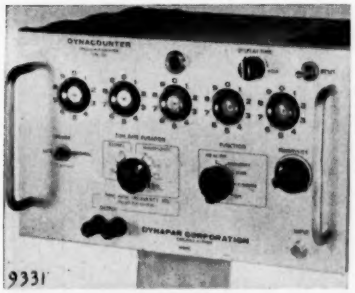


curacy is essentially independent of line voltage between 100 and 125 v ac. It is a heavy-duty plug-in packaged unit in a watertight case. Single calibrated dial covers range from 0.05 sec to 2 sec; other ranges are available. Three relay load outlets are rated for 2 amp, 115 v ac.—*C. W. Logeman Co.*, 633 *Bergen St., Brooklyn* 38, *N. Y.*

For more information circle **280** on inquiry card.

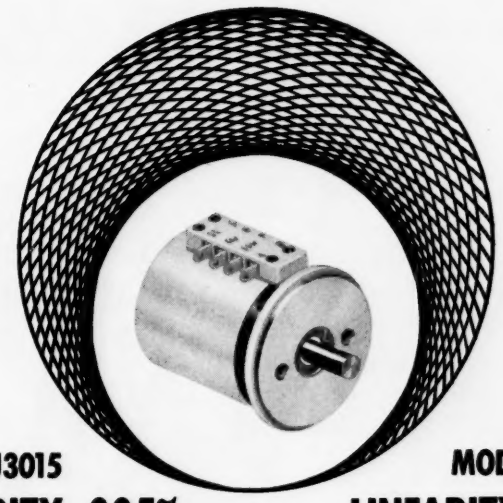
FREQUENCY COUNTER

New 15-lb Type 350 frequency counter uses a crystal time standard (oven type available); covers 10 cps



to 100 kc; time base duration from 10 μsec to 1 sec in decade steps; display time from ½ sec to 5 sec, or HOLD.—*Dynapar Corp.*, 5150 *Church St., Skokie, Ill.*

For more information circle **281** on inquiry card.



MODEL J3015 **MODEL F1810**

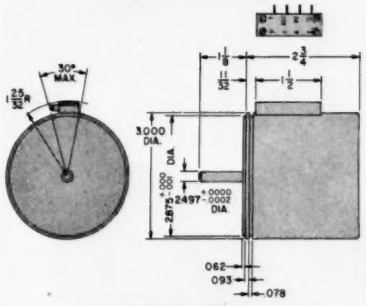
LINEARITY .005% **LINEARITY .01%**

HIGH PRECISION POTENTIOMETERS

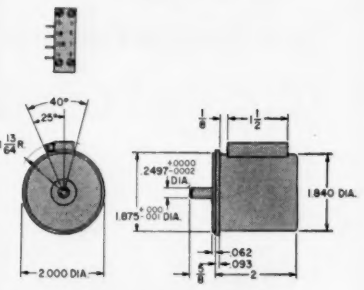
IMMEDIATELY AVAILABLE IN PRODUCTION QUANTITIES

SAMPLES SHIPPED IN 48 HOURS

15 TURN – 3 IN. DIA.



10 TURN – 1.8 IN. DIA.



MODEL J3015	
RESISTANCE RANGE	2K TO 150 K
LINEARITY (STANDARD)	.05% TO .01%
LINEARITY (BEST)	.005% ABOVE 4 K

MODEL F1810	
RESISTANCE RANGE	1 K TO 50 K
LINEARITY (STANDARD)	.05% TO .02%
LINEARITY (BEST)	.01% ABOVE 2K

Now you can design your circuits with Analogue Controls Potentiometers with the assurance that they will be available when you need them!

Complete mechanical and electrical specifications of all our potentiometers are available. Write for Catalog P103 today.

POTENTIOMETERS MEET THE REQUIREMENTS OF NAS-710

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Los Angeles 22, California

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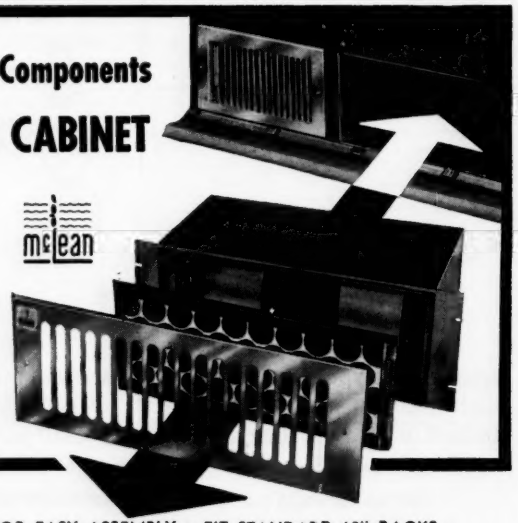
Save Sensitive Components

COOL THAT CABINET

WITH

McLEAN FANS & BLOWERS*



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RACK MOUNTED FOR EASY ASSEMBLY • FIT STANDARD 19" RACKS

Models Available for 5¼", 7" and 10½" Panel Heights • Wide Range of Air Deliveries

GENERAL FEATURES

- Pressurizes Cabinet With Filtered Air
- Rubber Isolated Motors For Quieter Operation
- Widely Accepted for Use in Military Equipment
- Maximum Air Delivery For Efficient Filter Action

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ADDITIONAL FEATURES FOR BLOWER TYPE UNITS

- Blower Units Provide Better Air Delivery Against Pressure
- Blower Units Provide Quieter Operation Against Pressure
- Higher Air Velocity For Faster Cooling
- Air Flow Maintained With Dirty Filter
- Duct Connections Can Be Made If Desired

Install McLean Fans and Blowers in Computers, Control Systems, etc. They're small, ready to use, packaged units with smart stainless steel grilles and easily replaceable filters. Standard RETMA notching allows mounting on rack without cutting or fitting.

McLEAN ENGINEERING LABS.
PRINCETON, NEW JERSEY
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Representatives in all principle Electronics manufacturing areas

For more information circle **100** on inquiry card.

NEW INSTRUMENTS

ELECTRO-MECHANICAL COUNTER

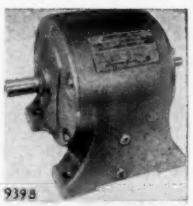
New unit adds, subtracts, and totalizes. Totalizer will operate best with a counting pulse ratio of 50%

on, 50% off. A life of 300 million counts, count rate up to 60 per second, electrical or manual reset by a single-stroke push bar, switch readout circuitry which makes possible accurate programming.—*Autron Engineering, 1254 W. Sixth St., Los Angeles 17, Calif.*

For more information circle **282** on inquiry card.

SPEED REDUCERS

New "StraitLine" in-line speed reducers are available in double and triple reduction. Double-reduction



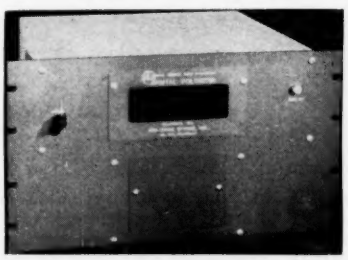
units are offered in 15 standard ratios from 3.39:1 to 57.3:1 with ratings up to 100 hp; triples in 9 ratios from 82.1:1 to 190.7:1—up to 50 hp.—*Western Gear Corp., P. O. Box 182, Lynwood, Calif.*

For more information circle **283** on inquiry card.

ELECTRICAL, ELECTRONIC INSTRUMENTS

DIGITAL MILLIVOLTMETER

New Model 4613 makes possible rapid, accurate measurement and instant display of millivoltages from



thermocouples, strain gages, etc. with automatic range-changing and

automatic standardization against standard cells. Is available with automatic print control for operation of Clary printers and IBM summary punch. Other accessories include multichannel input scanner, and remote digital readouts. Does not require a preamplifier, nor does it use potentiometers or slide wires. Ranges of 0 to ±9.999 mv and ±10.00 to ±99.99 volts are automatically selected.—*Non-Linear Systems, Inc., Del Mar, Calif.*

For more information circle **284** on inquiry card.

PHASEMETER

New PM-lb phasemeter is applicable at audible and supersonic frequencies. Using neither tubes nor semi-conductors, the phasemeter will retain its ±½% calibration accuracy for ex-

tended periods. Single-frequency unit is available at any frequency from 60 cps to 20 kc; three-frequency unit can be provided for any selected 3 frequencies in same range.—*Statham Development Corp., Dept SP-4, 12411 W. Olympic Blvd., Los Angeles 64, Calif.*

For more information circle **285** on inquiry card.

GALVANOMETER-AMPLIFIER

New Model 204A electronic galvanometer is combination dc null detector, linear deflection indicator, microvoltmeter, micro-microammeter, and low-level dc amplifier functionally

equivalent to suspension galvanometer. Chopper stabilized, all-transistor circuit is insensitive to vibration, shock, microphonics, earth's magnetic field and stray pickup. Seven decaded ranges cover dc voltages from 10 microvolts to 10 volts full scale, or currents from 0.001 microamp to 1 milliamp full scale.—*KIN TEL 5725 Kearny Villa Rd., San Diego, Calif.*

For more information circle **286** on inquiry card.

GYROS
for every application

The Kearfott miniature 4 Gimbal 3 Gyro, stable platform, provides precise azimuth, pitch and roll information—irrespective of the airframe attitude. It is hermetically sealed for environmental protection. Because of its rapid warmup characteristic, this unit is fully operational in less than five minutes. This platform provides the features of a magnetic slaved or a latitude corrected directional gyro for heading reference. Dependable, accurate single purpose Kearfott Gyros also available.

ALL ATTITUDE 3 GYRO STABLE PLATFORM

Suitable for use in both missile and aircraft, random drift rate 1° per hour in azimuth and 3° per hour in vertical. Measures only 8" Diam. x 8¾" High, weighs but 23 lbs.

Send for bulletin giving data of components of interest to you.

KEARFOTT COMPONENTS INCLUDE:

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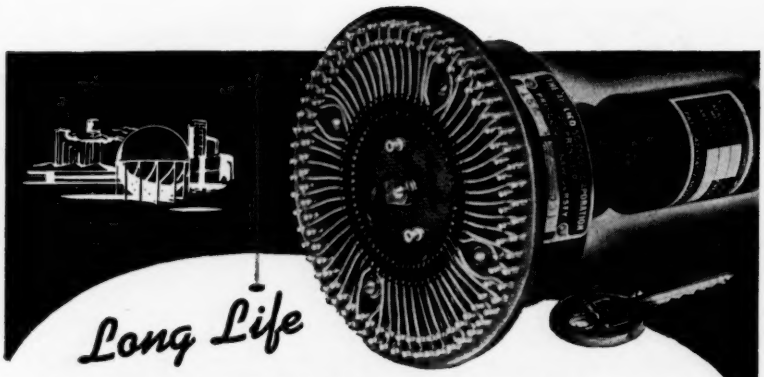
For more information circle **101** on inquiry card.



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ASCOP, the leading manufacturer of rotary sampling switches, for industrial, scientific and military uses, has over 200 standard models for automation, instrumentation, telemetering, display and countless other applications.

ASCOP switches feature reliability, accuracy and trouble free operation. Up to 240 contacts per pole are available. Whether your problem requires a standard switch or a special design, rely on the leader . . .

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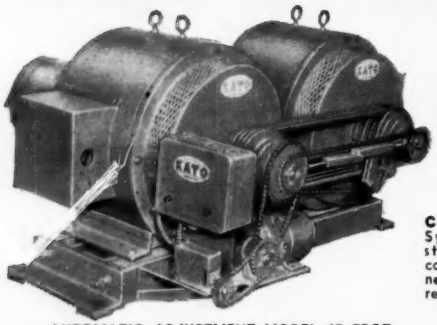
For more information circle **102** on inquiry card.

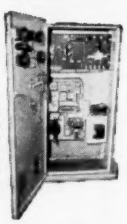
For Better Bench Mock-Up Tests

KATO VARIABLE FREQUENCY MOTOR GENERATOR SETS



REMOTE CONTROL

Remote control frequency adjustment varies speed from 1080 to 1320 RPM, thus varying frequency. Bench mock up test station may be located anywhere.



CONTROL PANELS

Synchronous motor starter and generator controls, including magnetic amplifier voltage regulator in cabinet.

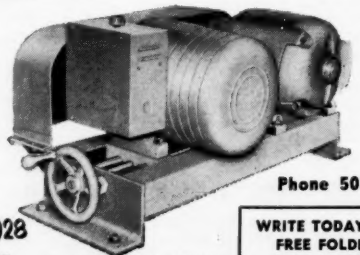
AUTOMATIC ADJUSTMENT MODEL 45 EPOT

Fully automatic variable frequency motor generator set adjusts 360 to 440 CPS. Generator mounted controls include reset buttons, limit switch. Motor and generator remain stationary. Vari-drive pulley adjustment controlled by small motor.

Also, AC Generators, 60 Cycle From 350 Watts to 500 KVA.

MANUAL ADJUSTMENT MODEL 28XA08

Easily adjusted by simple hand wheel controlling variable pitch pulley V-belt arrangement. This motor generator set gives 45 to 60 cps output. Unit holds speed accurately. Frequency meter on generator panel indicates output. Single phase generator speed varies from 1350 to 1950 rpm.



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Builders of Fine Electrical Machinery Since 1928

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WRITE TODAY FOR FREE FOLDER! IT'S NEW!

For more information circle **103** on inquiry card.

NEW INSTRUMENTS

60-CPS CHOPPERS

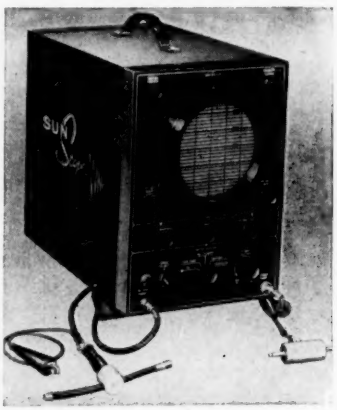
New "Microverter" can convert low-level dc signals such as produced by thermocouples and photocells (10μv)

into a low-level ac signal. Also can be used as a synchronous rectifier to convert low-level ac signals to dc without loss. Standard coils with d-c resistances from 13 ohms to 7,950 ohms are available for a driving voltage range from 0.5 v to 12 v rms.—*Barber-Colman Co., Electrical Components Div.,* 1400 *Rock St., Rockford, Ill.*

For more information circle **287** on inquiry card.

ENGINE TESTER

New Model SS for automotive ignition analysis can be operated by personnel who have had no previous



experience with oscilloscope. Pattern interpretation has been greatly simplified. Cylinder performance comparison is made possible by displaying all cylinder patterns across the screen, individually or in normal firing order.—*Sun Electric Corp., Chicago* 31, *Ill.*

For more information circle **288** on inquiry card.

PACKAGED THYRATRON AMPLIFIERS

New Thyraline amplifiers, with tube ratings from 2.5 through 18 amps output current, single phase, 2 phase and 3 phase, are designed for vertical panel board mounting. Any type of motor drive positional servo, lighting or heating controller can easily be put in operation by connecting control elements, control voltages or currents, load and feedback transducers.—*Hanson-Gorrill-Brian, Inc.,* 85 *Hazel St., Glen Cove, N. Y.*

For more information circle **289** on inquiry card.

UNIVERSAL POTENTIOMETER

New Alnico Model P-55 is potentiometer and millivolt source in one instrument; 4⅛" x 4½" x 7½"; weighs

3½ lb; can be used with thermocouple, or to measure any potential in 0-to-55 mv range. Dual input provides two sets of 5-way binding posts.— *Allegany Instrument Co., Inc.*, 1091 *Wills Mt., Cumberland, Md.*

For more information circle **290** on inquiry card.

DIGITAL VOLTMETER

New Model 100A, digital voltmeter features 0.1% or 1-count accuracy and reading rate as high as 70 per second.

Input: 0 to 130 v. Unit can supply power for external scale-changing amplifier; can be used as a counter, timer or repetition-rate instrument; contains decimal point locator and both decimal and binary coded output (1-2-2-4). Four digit (0.01%) accuracy models also available.—*Electronic Computer Co.*, 6191 *Ridge Ave., Phila.* 28, *Pa.*

For more information circle **291** on inquiry card.

CURRENT DRIVERS

New Type 3003 and 3004 current drivers test square-loop tape-wound magnetic cores. Type 3003 driver is a

high-impedance high-current source and produces negative current pulses; Type 3004 is designed for low-impedance operation functioning as a cathode follower and producing positive current pulses. Each unit has identical coarse and fine adjustment of rise-time (0.2 to 1.0 μsec), duration (1.0 to 10 μsec), and amplitude (up to 1.0 amp.) of the rectangular output current pulse.—*Burroughs Corp., Electronic Instrument Div.*, 1209 *Vine St., Phila.* 7, *Pa.*

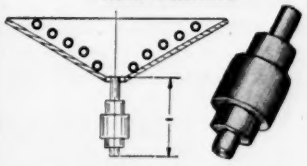
For more information circle **292** on inquiry card.

The Lepel line of induction heating equipment represents the most advanced thought in the field of electronics as well as the most practical and efficient source of heat yet developed for industrial heating.

If you are interested in induction heating you are invited to send samples of the work with specifications. Our engineers will process and return the completed job with full data and recommendations without any cost or obligations.

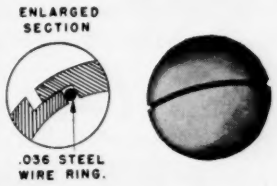
TYPICAL INDUCTION HEATING APPLICATIONS

TEMPERING FOR CUSTOM HEAT TREATING



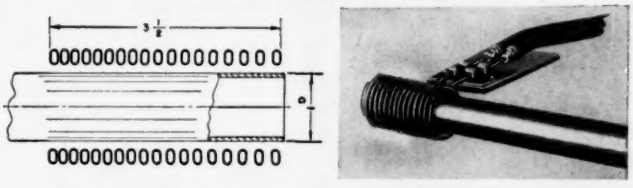
Selected areas of hardened steel parts may be tempered for fabrication or service requirements. Concentrator type coil permits high power density in restricted area thus minimizing heating time and permitting marked variation in properties in adjacent sections.

WIRE RING JOINS PLASTIC PARTS



High frequency induction heats wire ring which in turn heats plastic wall, providing sufficient plasticity to cause flow and bonding upon application of pressure. Metal to plastic seals are similarly performed.

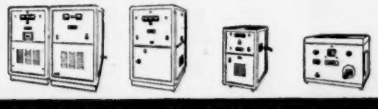
ANNEALING ALUMINUM FURNITURE TUBING



Selective annealing of aluminum furniture tubing permits bending where required without loss of strength in adjacent portions of tube. Brass or steel tubing is also being selectively annealed.

Electronic Tube Generators from 1 kw to 100 kw.
Spark Gap Converters from 2 kw to 30 kw.

WRITE FOR THE NEW LEPEL CATALOG . . . 36 illustrated pages packed with valuable information.



All Lepel equipment is certified to comply with the requirements of the Federal Communications Commission.

LEPEL HIGH FREQUENCY LABORATORIES, INC.
55th STREET and 37th AVENUE WOODSIDE 77, NEW YORK CITY, N. Y.

For more information circle **104** on inquiry card.

WesCo has hundreds of Aircraft and Industrial solenoids

Look to **WesCo** engineers with your aircraft or industrial solenoid problem. Hundreds of proven designs available. **WesCo** will modify or furnish special designs to fit your specifications.

Here are some of the features available:
High temp units tested past 600°F. • Adjustable plunger travel • Plunger cavity pressure sealed • Push or pull types 12 to 115 volts • Miniature, medium and heavy duty types • 400 cycle AC units also available.

Remember, when you need a solenoid, think of **WesCo AC INDUSTRIAL SOLENOIDS**—full line. Write for brochure. **DC AIRCRAFT SOLENOIDS**—send specifications, or write for catalog.

The trademark on millions of solenoids since 1927

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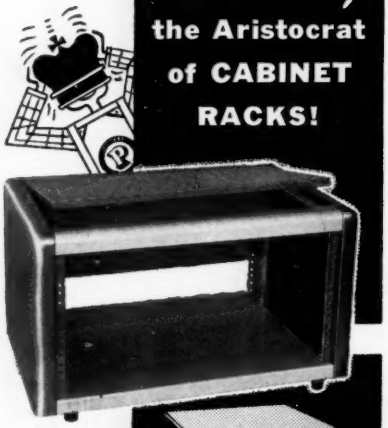
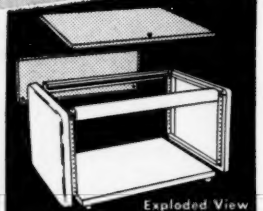
For more information circle **105** on inquiry card.

Introducing the Aristocrat of CABINET RACKS!



POR Series



Exploded View

See our BOOTH 1316
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August 20-23
SAN FRANCISCO

CONTACT YOUR LOCAL DISTRIBUTOR OR SEND FOR SHEET NO. S-108

NEW and DIFFERENT

PREM-O-RAK *by* PREMIER

AVAILABLE IN 20 DIFFERENT SIZES—FROM 7" to 35" PANEL SPACES

BOTH 15¼" and 18" DEEP FOR STANDARD 19" PANELS

- Shipped knocked down for easy assembly, storage and shipping.
- Handsomely finished in two-tone Gray and Brown Hammertone.
- Both front and rear of top have attractive ball corners.
- Panels may be mounted on both front and rear if desired.
- Interlocking removable top and rear panels made of perforated metal and held by captive screws.
- Panels fit into ½" recess. Base supplied with 4 rubber feet.
- Components may be mounted on base before assembly of rack into a complete unit.
- Screws for assembling not visible from outside.

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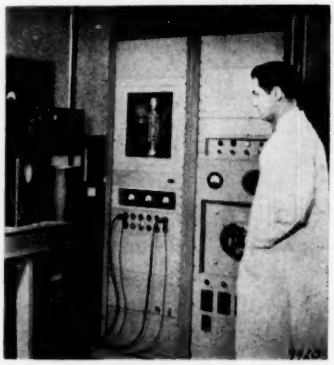
For more information circle **106** on inquiry card.

NEW INSTRUMENTS

ULTRASONIC AMPLIFIER-GENERATOR

New "Vari-Sonic" utlrasonic amplifier-generator, capable of producing 1500 w, has continuous output vari-



ability over frequency range of 3000 to 40,000 cps; is flat from 10 kc to 35 icc (±1.5 dl). Output impedance is adjustable from 0 to 200 ohms in 10 steps.—*Designers for Industry, Inc., 4241 Fulton Parkway, Cleveland 9, Ohio.*

For more information circle **293** on inquiry card.

AC VOLT-OHM-AMMETER

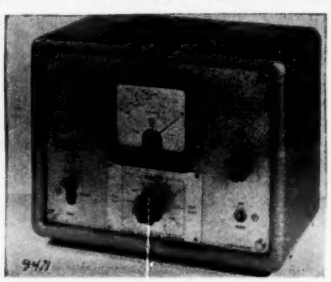
Newly Swedish-made precision-multi-range-instrument Model 1 AVe, featuring 0.2% accuracy and iron-

shielded electrodynamometer movement.—*Oltronix Co., 235 Underwood Dr., N. W., Atlanta 5, Ga.*

For more information circle **294** on inquiry card.

MEGOHMMETER

New Model 35A Myria megohmmeter (British made) covers 50,000 ohms to 200,000 megohms over 10 ranges with 2 fixed test potentials (100 and 500 vdc); is said to be first

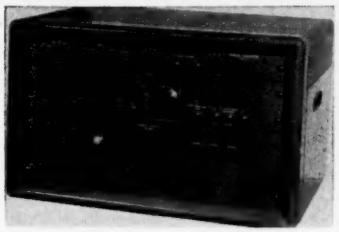


of its kind to be calibrated in conductance as well as resistance; is especially suitable for testing highly capacitative circuits. Short circuit test current is limited to 10 ma; accuracy is generally better than 1.2% of full scale of each range expressed in terms of conductance.—*Herman H. Sticht Co., Inc., 27 Park Place New York 7, N. Y.*

For more information circle **295** on inquiry card.

DELAY GENERATOR

New precision Delay Generator Type 6010 features accurate, variable, time interval pulses. Consists of

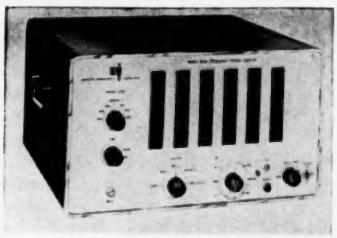


three modular constructed unit—(1) Trigger Generator Type 101 provides standard negative pulse output from an input signal composed of slow rising sine waves or fast rise time kc, (2) Delay Generator Type 131 produces five, precise, stable outputs; both positive and negative delayed pulses, positive and negative gating pulses, and a linear negative going ramp function; (3) Power Supply Type 9804.—*Electronic Instrument Div., Burroughs Corp., 1209 Vine St., Phila. 7, Pa.*

For more information circle **296** on inquiry card.

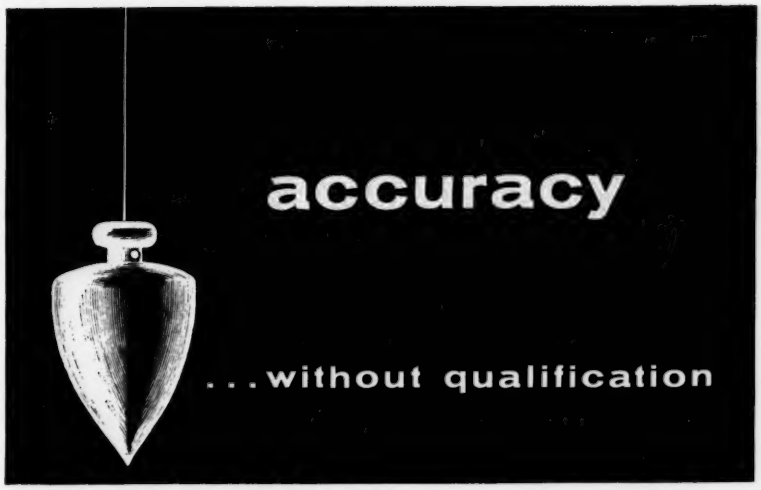
FREQUENCY-PERIOD COUNTER

New Model 203A Frequency-Period Counter offers 0 cps to 1 Mc direct reading operation for frequency and



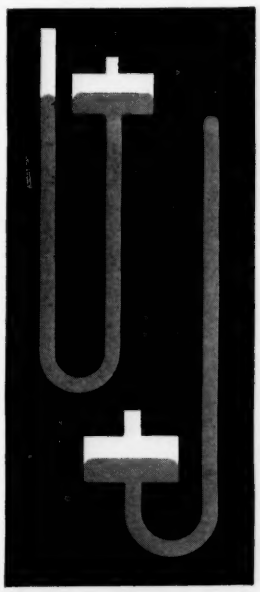
period (1/frequency) measurement. Other typical applications of the CMC Model 203A are measurement of pressure, temperature, velocity, acceleration, flow, RPS, RPM, displacement, etc., which may be measured with suitable transducers. The instrument also serves as a secondary frequency standard. Continuously adjustable trigger level control permits full rated sensitivity at any voltage level between −300 and +300 volts. Features: automatic decimal point indication. Time base range of 10 microseconds to 10 seconds in decade steps (frequency), 1 and 10 cycles (period).—*Computer-Measurements Corp., 5528 Vineland Ave., N. Hollywood, Calif.*

For more information circle **297** on inquiry card.



Absolute Pressure Measurement

Manometers are ideally suited to absolute pressure measurement applications. The raised-well type (left) is adjusted for prevailing barometric pressure; the sealed-tube type (right) is self-compensating for barometric pressure changes. Both read directly in terms absolute.



With other forms of instrumentation, you wonder. With the manometer, you know . . . accuracy is unqualified; it's timeless.

There is never a question of calibration or re-calibration. Whether it is brand new or years old, a manometer is *never* in error. It is operated by the force of gravity, and gravity never fails.

It is only this type of accuracy that offers true reproducibility for the plant engineer and reliable data for the laboratory technician.

Despite this perfect accuracy, the Meriam Manometer is lowest in cost . . . simplest to maintain of all instrumentation forms.

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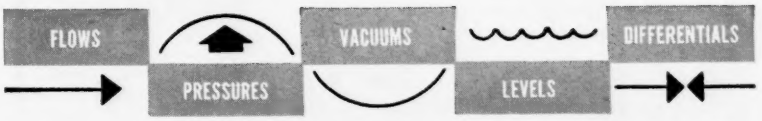
. . . complete and informative guide to manometer theory and practice as well as manometer models for plant, field and laboratory use. Just ask for Bulletin G-14. The Meriam Instrument Company, 10920 Madison Avenue, Cleveland 2, Ohio.



MERIAM MANOMETERS

...always accurate

For more information circle **107** on inquiry card.

PRECISION POWER OSCILLATORS

PRICE
$119.00

MODEL 1040

SPECIFICATIONS

Frequencies.....400 or 1000 C.P.S. by selector switch (other frequencies on request)
Distortion.....Less than 1 %
Hum Level.....Approximately .05 % of rated output
Output Power...3 watts into matched resistive load
Power Supply...115 volts, 60 C.P.S., 40 watts
Dimensions.....5-11/16 x 9 x 6⅛ inches

OTHER MODELS AVAILABLE

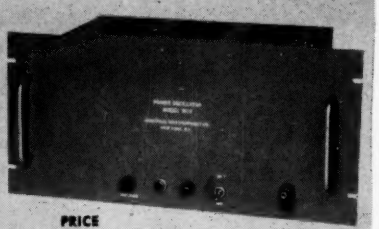
MODEL	DESCRIPTION	POWER OUTPUT
1040A	Sim. to Mod. 1040	8 watts

EXCELLENT ACCURACY AND STABILITY • TRANSFORMER ISOLATED OUTPUT • 3 OUTPUT IMPEDANCES • LOW INTERNAL IMPEDANCE • OUTPUT VARIABLE UP TO 120 VOLTS

MODEL 1500

SPECIFICATIONS

FREQUENCY.....400 CPS (Other frequencies on request)
Distortion.....Less than ½ %
Hum Level.....Approximately .02% of rated output
Output Power.....15 watts into matched resistive load
Power Supply.....115 volts, 60 C.P.S., 120 watts
Dimension.....8¾" x 19" rack panel, 8" deep



PRICE
$299.00

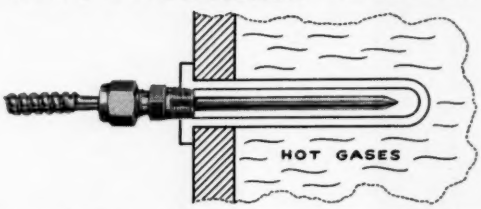
Representatives in Principal Cities

INDUSTRIAL TEST EQUIPMENT CO.
55 EAST 11th STREET • NEW YORK 3, N. Y.

For more information circle **108** on inquiry card.

Thermocouple Life Increased Up To 135 Times

With T-E's *Ceramo*® Construction



For measuring all types of process temperatures, T-E's "Ceramo" construction—ceramic insulation, metal sheathing—provides a tremendous increase in thermocouple life over conventional, open-end types. In a typical application, enclosed hot junction, ⅛" O.D. "Ceramo" thermocouples were used recently in a hydro carbon cracking unit operating continuously at 1616° F. "Ceramo" thermocouples lasted 7 to 9 months—*while 14 gage bare wire thermocouples lasted but 2 to 14 days.* And there was no significant difference in response. "Ceramo" thermocouples are available in all standard calibrations. Overall diameters—1/25" to 1-7/16".

Write for Bulletin 325-F.

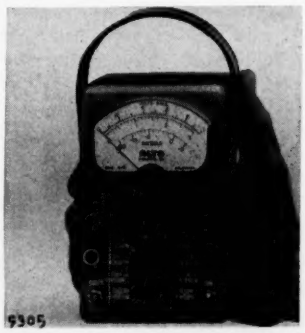
Thermo Electric Co., Inc.
SADDLE BROOK, NEW JERSEY
In Canada—THERMO ELECTRIC (Canada) Ltd., Brampton, Ont.

For more information circle **109** on inquiry card.

NEW INSTRUMENTS

30-0Z VTVM

Three new "D-21 Series" transistorized vacuum tube voltmeters have frequency ranges 10 cps to 1 Mc, 5 cps



to 500 kc, and 10 cps to 500 kc. Accuracy is better than 3% throughout most of range and within 5%, full range. Relay rack mounts are available with two to five voltmeters mounted side-by-side.—*Alto Scientific Co., 855 Commercial St., Palo Alto, Calif.*

For more information circle **298** on inquiry card.

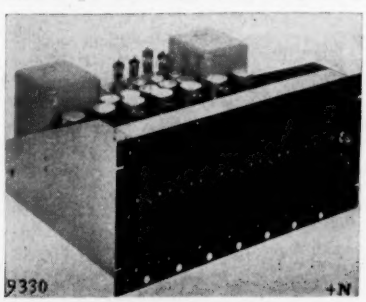
PUNCH-CARD TUBE TESTER

New portable Automatic Electron Tube Tester (WT-110A) performs tests for transconductance, interelectrode shorts and leakage, and gas content. Reducing setup time and operation to a few seconds, the tester performs automatic selection of operating parameters for the vacuum tube under test by means of pre-punched computer-type information card.—*Radio Corp. of America, RCA Bldg., 30 Rockefeller Plaza, New York 20, N. Y.*

For more information circle **299** on inquiry card.

AC AMPLIFIER SYSTEM

New 7-channel a-c voltage amplifier system is exceptionally linear in phase and amplitude characteristics from 2



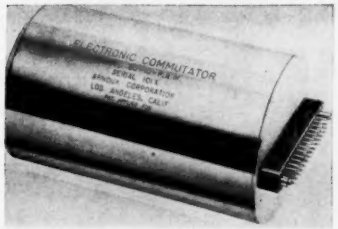
cps to 100,000 cps. Each channel can be set to any of 11 steps of voltage gain from unity to 100 without degradation of signal-to-noise ratio by excessive attenuation of input signal.—*Dynamics Instrumentation Co., 1118 Mission St., So. Pasadena, Calif.*

For more information circle **300** on inquiry card.

SWITCHES, RELAYS

ELECTRONIC COMMUTATOR

New Series ETC-30 electronic commutator for airborne telemetry applications, said to be the first commercially available unit of its kind, is offered with any sampling rate from 75 to 900 points per second. Meets all IRIG requirements for PAM

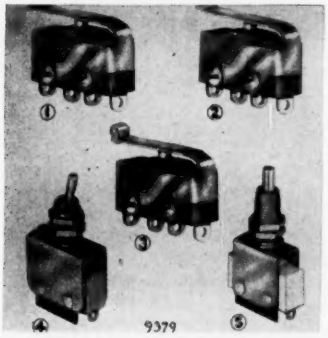


and PDM commutated telemeter and magnetic tape systems under MIL E-5272A environment; can be used as a direct replacement for mechanical commutators in 0-3 and 0-5v systems. Errors due to drift, cross-talk and non-linearity are less than 0.50%. Maintenance-free longevity is 5000 hrs.—*Arnoux Corp., 11924 W. Washington Blvd., Los Angeles 66, Calif.*

For more information circle **301** on inquiry card.

SWITCH ACTUATORS

Five new switch actuators—(1) leaf, (2) frame leaf, (3) roller leaf, (4) toggle and (5) plunger are now



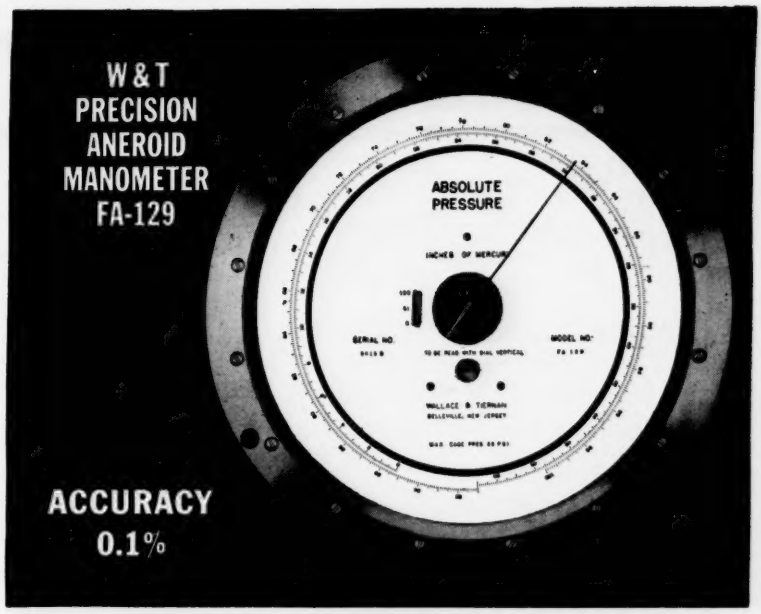
available for use with recently perfected subminiature switch rated 10 amp at 125-250 vac, ¼ hp 125 vac and 10 amp 28 vdc and, according to maker, has a rating four times higher than switches of comparable size.—*Acro Div., Robertshaw-Fulton Controls Co., Columbus 16, Ohio.*

For more information circle **302** on inquiry card.

ROTARY GROUNDING SWITCH

New three-position rotary grounding switch permits easy adjustment of signal strength for local, intermediate and fringe reception. Twist-tab mounting permits quick, low-cost assembly.—*P. R. Mallory & Co., Inc., Indianapolis, Ind.*

For more information circle **303** on inquiry card.



PRECISE CALIBRATING STANDARD
...For Absolute Pressure Work

Ranges: 0 to 31.5 inches of Hg. absolute (min.)
0 to 100 inches of Hg. absolute (max.)
Other intermediate ranges available

Accuracy: 1/1000 of full scale

Sensitivity: 1/10,000 in *all* ranges

Scale Length: 45 inches in two revolutions

Dial Size: 8½ inch diameter

Write for Publication No. TP-15-A

WALLACE & TIERNAN INCORPORATED
25 MAIN STREET, BELLEVILLE 9, NEW JERSEY
In Canada, Wallace & Tiernan, Ltd. — Toronto
A-112

MERCHEN GRAVIMETRIC FEEDERS & METERS

for dry free-flowing materials

- automatic batch control
- continuous blending
- materials accounting

Accuracy 1%
Rates 3 to 3000 lbs. per min.

Write for Bulletin No. M-32

WALLACE & TIERNAN
INCORPORATED
25 MAIN ST., BELLEVILLE 9, N. J.

For more information circle **110** on inquiry card.

AN OPPORTUNITY AND A CHALLENGE
FOR COMPONENT AND SYSTEMS DESIGNERS

SIMPLIFY AND INCREASE SYSTEM RELIABILITY

BY DESIGNING TO CHARACTERISTICS OF LOW IMPEDANCE A-C DIFFERENTIAL TRANSFORMERS

infinite resolution • no sliding contact nor bearings
frictionless • unlimited life, nothing to wear out
temperature stable • high signal to noise ratio
small, compact, lightweight

Recommended for hydraulic servo valve feedback, rate gyros, accelerometers, hydraulic servo motors, pressure, flow, position and level detectors, Atcotran Differential Transformers are setting the pace for improved reliability of components in existing systems by replacement of sliding contact pickups.

New systems designs incorporating the full advantage of inherent characteristics of these transducers promise outstanding benefits:

1) The low impedance characteristics of differential transformers can reduce or eliminate the need for filter circuits.

2) Ratio winding techniques and simple interconnection for algebraic functions frequently can be accomplished without intermediate components.

3) The reliability and precision of differential transformers makes possible a new order of performance.

EXPERIMENTAL KIT

To enable designers to familiarize themselves with the application of differential transformers in the laboratory, the Atcotran Differential Transformer Experimental Kit has been made available. It contains seven standard coils of various characteristics, a flexure plate and clamp, a demodulator and a 32-page HANDBOOK containing theory and application data on differential transformers.

A $324.00 value specially priced at only $189.50 for lab investigation.
Start exploring this new opportunity now. Order your kit today.

atc®
THE WORLD'S LEADING DESIGNERS AND MANUFACTURERS OF LOW IMPEDANCE DIFFERENTIAL TRANSFORMERS

AUTOMATIC TEMPERATURE CONTROL CO., INC.
SUBSIDIARY OF SAFETY INDUSTRIES, INC.
5224 Pulaski Avenue, Philadelphia 44, Pa.

Please send me an Atcotran Differential Transformer Experimental Kit and invoice $189.50 against our purchase order No._____

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ADDRESS_____
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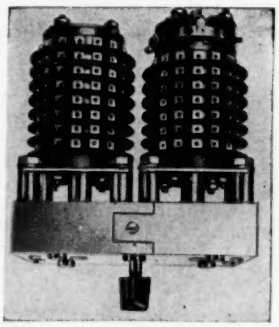
FOREIGN SALES: ATC EXPORT DEPARTMENT, 1505 RACE ST., PHILA. 2, PA.

For more information circle **111** on inquiry card.

NEW INSTRUMENTS

GEARED ROTARY SWITCH

New gear-operated pairs of 16-position, 12-section Type HT rotary switches double the number of elec-



trical circuits that can be controlled by a single knob. Keep switch length to a minimum and assure positive positioning of rotors at each 22-1/2° angle of rotation of the switch handle.—*Electro Switch Corp., Weymouth 88, Mass.*

For more information circle **304** on inquiry card.

PHASABLE STACKING SWITCH

New switch stacks up to 20 poles. Every section contains two contact plates, each phasable with every other

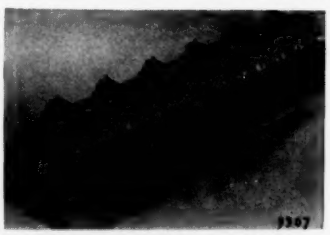


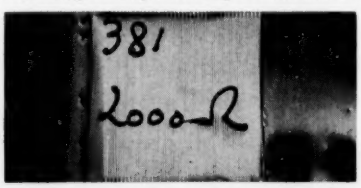
plate by screw adjustment. Plates can be made with one to three poles, with up to 90 contacts per pole. Up to 600 rpm switch speed.—*Applied Science Corp., Princeton, N. J.*

For more information circle **305** on inquiry card.

ELECTRONIC COMPONENTS

HALL EFFECT VARIABLE-RESISTANCE GRIDS

Bismuth grids, mounted on flexible plastic, having copper terminals for soldering leads, are easy to install in



air gap of magnets for non-contact gauss measurements, resistance measurements, and electronic control. Re-

sistance change in magnetic field follows Smithsonian tables. Current rating: 1-ma size #1 is stocked in resistance values of 3000-2500-1500-1000 ohms. Size #2 is stocked in values of 300-275-250-225-200-175-150 ohms.—*Fitzpatrick Electric Supply Co.*, 444 *Irwin, Muskegon, Mich.*

For more information circle **306** on inquiry card.

VITREOUS ENAMEL RESISTORS

New axial-lead vitreous enamel resistors, of 3-, 5-, and 10-watt ratings

have extreme resistance to thermal shock, high resistance to mechanical and humidity shock.—*P. R. Mallory & Co. Inc., Indianapolis, Ind.*

For more information circle **307** on inquiry card.

SILICON TRANSISTORS

Fifteen new silicon transistors in round welded cases operate stably at temperatures up to 150°C (302°F).

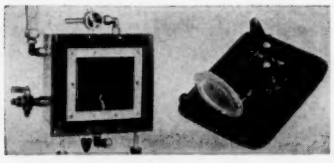
Include two switching transistors with total switching times down to 0.1 usec. These are n-p-n grown-diffused types featuring high alpha cutoff frequencies and low collector capacities. One designed for use in high-gain applications, the other for medium gain circuits. The other 13 include three high-frequency tetrodes, 5 medium-power devices, and 5 small signal transistors.—*Texas Instruments Inc.*, 6000 *Lemmon Ave., Dallas 9, Texas.*

For more information circle **308** on inquiry card.

HUMIDITY

HUMIDITY INDICATOR

New remote humidity indicator uses a vacuum pump (or line) to draw sampled air through the indicator.

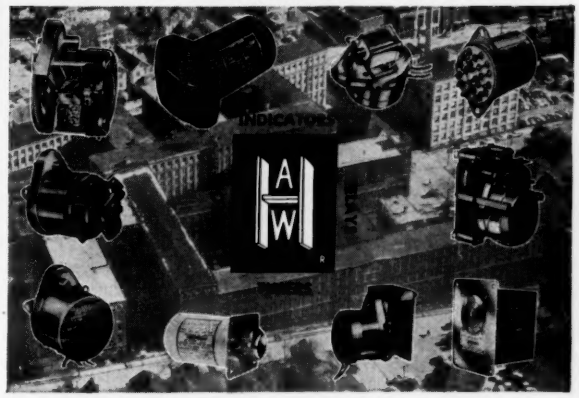


Only two connections are necessary; no wiring is needed, since operation is mechanical.—*Serdex, Inc.*, 91 *Cambridge St., Boston 14, Mass.*

For more information circle **309** on inquiry card.

one source for all timers!

the **A. W. HAYDON COMPANY** *offers a* **COMPLETE LINE** *of* **STANDARD** *and* **CUSTOM DESIGNED TIMING MOTORS** *and* **DEVICES!**



for military and industrial applications. Illustrated are some of these units . . . any can be modified to meet your specific requirements if the basic design is not adequate.

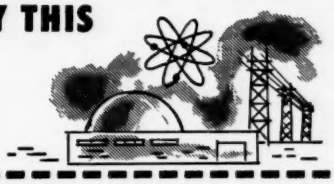
Shown below is the new catalog of the A. W. Haydon Company describing all of the basic types of units available and many of the "specials". Included in this 25-page catalog are 60 photographs of timers, 30 dimensional drawings, and 50 charts and diagrams. This complete catalog will be supplied on request.

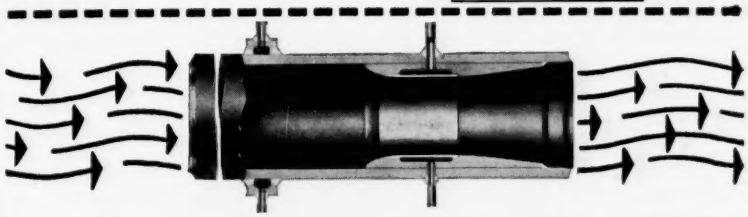
Long a pioneer in the timing field, The A. W. Haydon Company is prepared to assist you in solving your timing and control problems. When a solution to your problem has been reached, The A. W. Haydon Company is prepared to follow through with production geared to meet your requirements whether a basic timing unit or a highly specialized device is required.

the **A. W. HAYDON COMPANY**
22 NORTH ELM STREET
WATERBURY 20, CONNECTICUT
Design and Manufacture of Electro-Mechanical Timing Devices

For more information circle **112** on inquiry card.

PRODUCTIVE ATOMS POSED A "HOT" METERING PROBLEM . . . SOLVED BY THIS BUILDERS FLOW NOZZLE!!





This Flow Meter is in the primary loop of every major atomic reactor in America — from the Nautilus to the Shippingsport Power Plant.

- Only flow nozzle offering the accuracy, range, low head loss, freedom from upstream disturbances, and other desirable characteristics of the Venturi Tube.
- Built to ASME pressure vessel code.
- Designed for high temperature — high pressure applications (power plants, high pressure lines, atomic reactors, etc.).
- Nozzle can be factory inserted in any customer-supplied high cost, special pipe at considerable savings.
- Completely drainable on modified designs; modified versions excellent for slurries.
- Design based on the most comprehensive compilation of primary element/fluid flow data available anywhere.

Let Builders application engineers solve your flow metering problems.

BUILDERS-PROVIDENCE
DIVISION OF
B-I-F INDUSTRIES
METERS REGULATORS CONTROLS

Write Builders-Providence, Inc., 422 Harris Avenue, Providence 1, Rhode Island

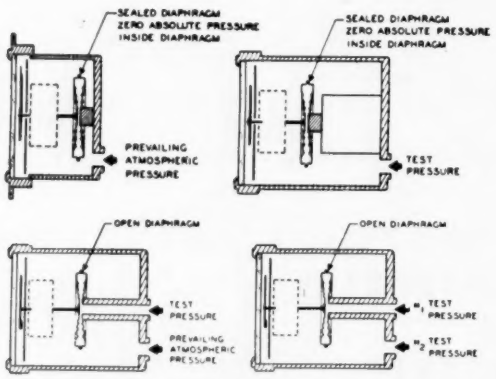
For more information circle **113** on inquiry card.

INSTRUMENTS and AUTOMATION Briefs

For this literature circle number on inquiry card.

Pressure Gages for Testing

ABSOLUTE PRESSURE: Absolute pressure is pressure measured above absolute zero. It is the sum of gage and barometric pressure . . . BAROMETRIC PRESSURE: Barometric pressure is atmospheric pressure above absolute zero, indicating prevailing atmospheric pressure . . . GAGE PRESSURE: Gage pressure is pressure measured above prevailing atmospheric pressure. Prevailing atmospheric pressure is considered zero gage pressure . . . VACUUM OR NEGATIVE PRESSURE: Vacuum or negative pressure is pressure measured below prevailing



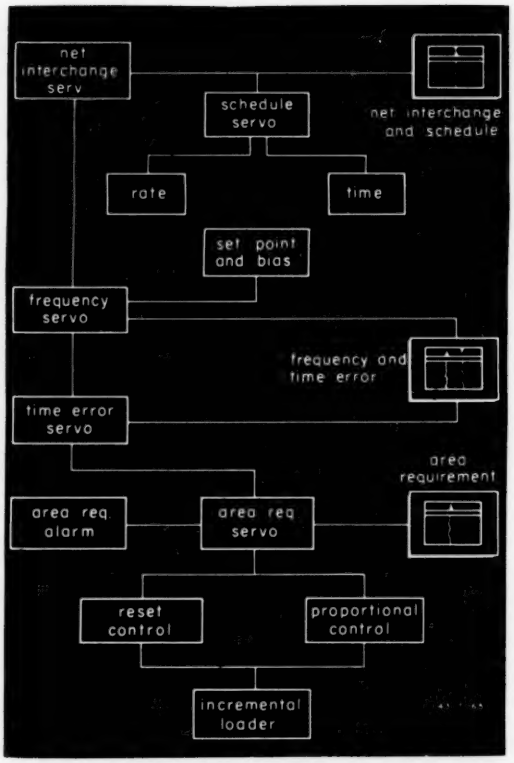
atmospheric pressure. Prevailing atmospheric pressure is considered zero vacuum or negative pressure. The maximum possible vacuum or negative pressure is equal to the prevailing atmospheric pressure . . . DIFFERENTIAL PRESSURE: Differential pressure is the pressure difference between two test pressures . . . (*From new* 12-*page Bulletin M* 106-7500, *Scientific Instrument Co.*, 1041 *Second Ave., Detroit* 26, *Mich.*)

For this literature circle **401** on inquiry card.

System Load and Frequency Control

Essentially, a load and frequency control system is an automatic method to compute area requirement accurately and change power generation as quickly as possible to meet the requirement. Most of the instrumentation for a system is centered in the load dispatcher's office or System Operation Center where the area requirement is computed and where command signals for the generating stations originate . . . Three of the data recorders tell the dispatcher how well the control system is working. These record frequency, net interchange, and area requirement . . .

The computing circuit is balanced only when the frequency and net interchange match the set points established by the dispatcher at the console. Any differences result in error signals to raise or lower generation. Time



deviation can also be included and supplies a third signal to a computing circuit. The three error signals are applied to the area requirement circuit so that they are added algebraically and result in a repositioning of the area requirement slidewire . . . (*From new* 24-*page Bulletin* 91-1, *Minneapolis-Honeywell Regulator Co., Industrial Div., Wayne and Windrim Aves., Phila.* 44, *Pa.*)

For this literature circle **402** on inquiry card.

Oscillograph

The Century Model 420 Electrograph is essentially a standard multi-channel recording oscillograph using light beam type galvanometers, but having the important added utility that the record can be observed within a fraction of a second and a permanent oscillogram is produced within a few seconds after exposure by the recording galvanometers . . .

The oscillogram has several noteworthy characteristics. First, it is a positive print; the traces and timing lines are opaque and will reproduce by Ozalid or similar processes. There is no tendency for the traces to fade, distort or otherwise deteriorate with time . . . (*From new* 4-*page bulletin "Electrograph Model* 420," *Century Electronics & Instruments, Inc.*, 1333 *No. Utica, Tulsa, Okla.*)

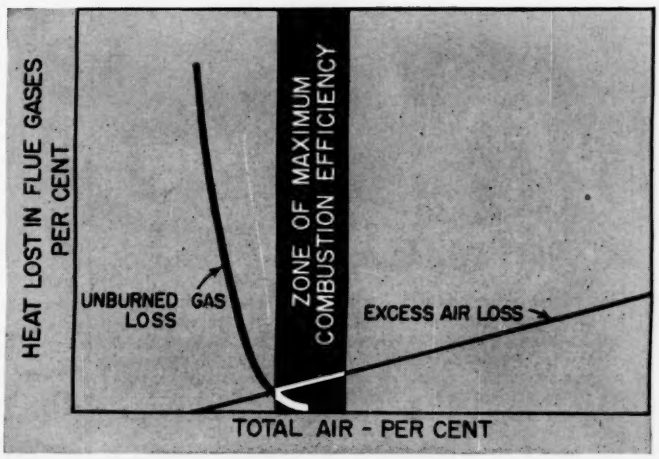
For this literature circle **403** on inquiry card.

How to get maximum combustion efficiency . . . measure both combustibles and oxygen

Simultaneous measurement of both oxygen and combustibles is needed to obtain optimum combustion. No instrument that measures only one of these two interdependable factors can give you the full information necessary.

Now, Bailey offers two units, each giving a continuous and simultaneous double check on combustion efficiency: a permanent analyzer-recorder which records both factors on a single chart; and a new light weight, portable unit which indicates both factors.

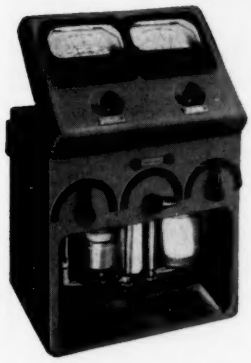
Both instruments measure: (1) excess air—regardless of the fuel or combinations of fuel being burned, (2) mixing efficiency of your fuel burning equipment by showing per cent combustibles in the flue gas.


HEAT LOST IN FLUE GASES PER CENT
UNBURNED GAS LOSS
ZONE OF MAXIMUM COMBUSTION EFFICIENCY
EXCESS AIR LOSS
TOTAL AIR - PER CENT

Maximum Combustion Efficiency is secured by keeping the sum of Excess Air Loss and Unburned Gas Loss to a minimum. To do so by the direct method simply measure both oxygen and combustibles in flue gas.

Both units are designed to increase efficiency in the furnace operations of the steel industry, on glass tanks, cement and lime kilns, ceramic and refractory kilns, steam boilers and also on direct and indirect-fired furnaces in the metal processing industries. To prevent your money from becoming waste gas, look into these two efficiency provers. A Bailey engineer will be glad to give you details or write us for product specifications.

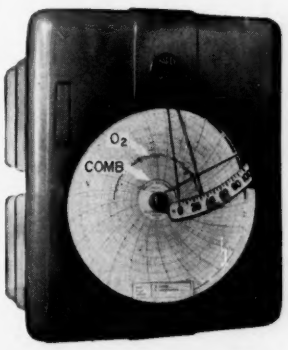
For portable use—
HEAT PROVER Analyzer



The famous Cities Service HEAT PROVER analyzer is now Bailey built and sold. Weighing only 25 pounds, it is a self-contained automatic analyzer including a sampling tip and hose plus a thermocouple for temperature measurement.

Instrument dials are dual range for greater accuracy and sensitivity.

For permanent installation
Oxygen-Combustibles Recorder



The Bailey Oxygen-Combustibles Analyzer-Recorder coordinates both records on one chart. These records enable the operator to keep fuel burning equipment performing continuously in the zone of maximum combustion efficiency. Excess air may be reduced to the point where combustibles begin to show.

G 40-1

Instruments and controls for power and process

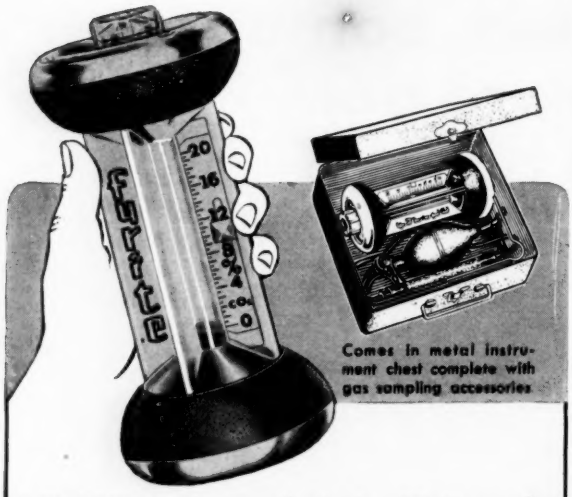
BAILEY METER COMPANY

1041 IVANHOE ROAD • CLEVELAND 10, OHIO

In Canada—Bailey Meter Company Limited, Montreal

BAILEY METERS

For more information circle 114 on inquiry card.



ACCURATE CO_2 Analysis in 40 Seconds!

Other outstanding features of the FYRITE CO_2 Indicator are its durable, fool-proof construction and unmatched convenience of operation. It requires no setting-up, has no valves or leveling bottle to manipulate.

The FYRITE measures CO_2 directly by the fundamental method of chemical absorption. Consequently, the reading is independent of voltage, humidity, temperature, or atmospheric pressure conditions.

Comes complete with chemical charge good for at least 300 readings. Replacing chemical merely requires removing four screws that hold top assembly in place.

Write for Bulletin 805

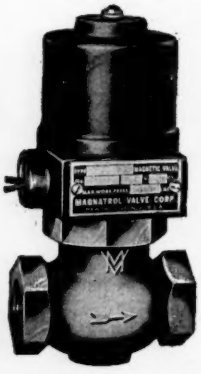
BACHARACH Industrial Instrument Company

200 N. Braddock Ave. • Pittsburgh 8, Pa.

For more information circle **115** on inquiry card.

Eliminate

Costly Flow Failures



Magnatrol

SOLENOID VALVES

Quick Operating *Non Sticking* *Tight Seating*

These three design advantages are your assurance against costly flow failures. Attain dependable, accurate, automatic or remote control of liquids or gases with **Magnatrol Valves.** Installed quickly and easily in connection with . . . flow-meters, thermostats, float and time switches. **Every Magnatrol Valve is delivered to you—factory tested—guaranteed free from defects in material and workmanship.**

Available in normally closed or normally open models. Pressure ranges from zero up to 300 PSI. Voltages to 575.

Catalog containing complete specifications mailed upon request.

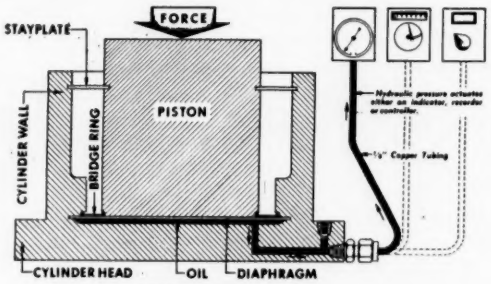
Magnatrol VALVE Corp.
HAWTHORNE 14
NEW JERSEY

For more information circle **116** on inquiry card.

Briefs—CONTINUED

Weighing Systems

The basic components of the Emery Hydraulic Weighing Systems are: the Emery Cell; a Tank Pivot Assembly; a Stay Strut Assembly; and the necessary instrumentation such as an indicator, recorder or controller.



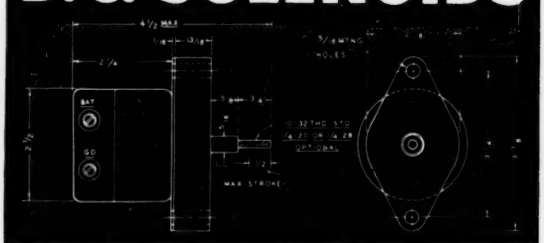
CROSS SECTION OF CELL

Weighing System . . . measures force by converting this force into exactly proportional pressures which, in turn, actuate either a suitable indicator, recorder or control device. Fig. 1 shows this operation diagramatically . . .

Fundamentally, the Emery Cell is a specially-designed rigid cylinder and piston mechanism with the piston held centrally in the cylinder by a flat, annular stayplate and a flat bridge ring. The metal diaphragm seals in a fluid layer not more than .030" thick . . . (*From new 12-page Bulletin* 561, *The A. H. Emery Co., New Canaan, Conn.*)

For this literature circle **404** on inquiry card.

D.C. SOLENOIDS



***Synchro-Start* SS SERIES SOLENOIDS**

are for operating engine throttles, fuel pump racks, chokes, etc. and are available with several variations.

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6V. 12V. 24V. 32V.

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50A. 30A. 17A. 7.5A.

CURRENT DRAW (Holding)
1.7A. .95A. .28A. .25A.

DUTY
Continuous

CYCLES
Not to exceed 6 per minute

PULL
Approximately 10 lbs. over ½" stroke

WEIGHT
2¼ pounds

SYNCHRO-START PRODUCTS, INC.
8151 N. RIDGEWAY AVENUE • SKOKIE, ILL.

For more information circle **117** on inquiry card.

Magmeter Detector

Airpax Magmeter Type F-992 is a frequency detector which develops an output current that is linear with input frequency over the range from 375 to 425 cps. The frequency detector can be used with a 50-microampere d'Arsonval indicating instrument, servo type recorder, or other average reading instrument, or it can feed directly into an automatic control equipment to provide control response to frequency . . . Basically Type F-992 detector consists of a saturable transformer as shown in Fig. 1. The input signal, whose frequency is to be measured, drives the Magmeter core to saturation during one half cycle. When the signal reverses, it again drives the core to saturation but in the opposite polarity . . .

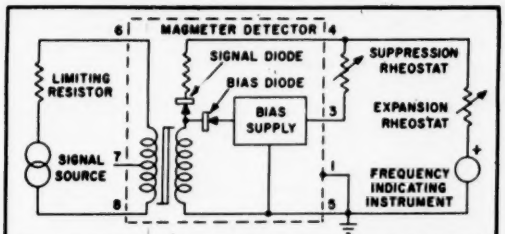
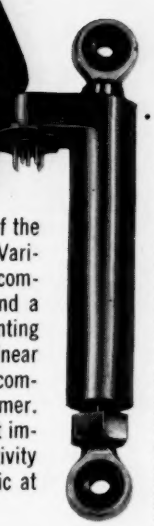


FIG. 1—SIMPLIFIED SCHEMATIC OF EXPANDED SCALE DETECTOR

The same technique for supplying bias current can be used to suppress the zero and thereby to place any comparable portion of the frequency range from 30 cps up to 5 kc on the indicating instrument . . . special Magmeter detectors have been designed for expanded scales in the vicinity of 60 cps. One has a band from 42 to 77 cps; other covers band from 57 to 63 cps . . . (*From new 8-page bulletin "Magmeter Detector," Airpax Products Co., Engineering Div., Middle River, Baltimore 20, Md.*)

For this literature circle **405** on inquiry card.

LATEST SCHAEVITZ LVDT



The unique mechanical design of the SCHAEVITZ 600 XS-AT Linear Variable Differential Transformer combines flexibility in alignment and a variable distance between mounting points with an unusually long linear range. The core assembly is completely separate from the transformer. The 600 XS-AT has a low output impedance and a very stable sensitivity versus temperature characteristic at 400 cps.

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TOTAL LINEAR TRAVEL: 1.200 inch
LINEARITY: within 0.5% of nominal output at 0.600 inch
OUTPUT (at 10 volt 400 cps input into a 0.5 megohm load): 6.4 volts at 0.600 inch displacement
AMBIENT TEMPERATURE RANGE: −65° to 225°F

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Pyrotest is 9 instruments in one, with 6 standard scales for thermocouples; 3 standard scales for millivolt readings. Special scales for any desired reading or use. Scales interchangeable in 30 seconds. Compact, rugged, easy to carry—12 lbs.; 12" x 9" x 8½". Accurate to 1/6 of 1%. Self-contained power supply. Write for new bulletin 9B.

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Write for our **new** bulletin on Precision Bore Tubing.

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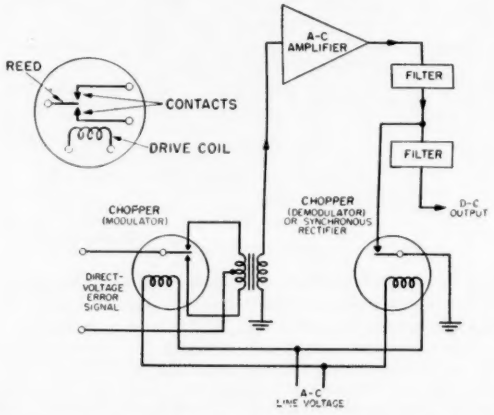
For more information circle **122** on inquiry card.

Briefs—CONTINUED

DC-AC Choppers

Application of an alternating voltage to the driver coil gives rise to an alternating magnetic field causing the reed to vibrate at the frequency of the voltage applied to the drive coil. The reed vibrates between a pair of contacts, one on either side. A direct-voltage source connected between the reed and the two contacts in parallel is thus interrupted at twice the driving frequency . . .



Stevens-Arnold offers two different types of choppers. First, there are the conventional types made for operation at 94 and 120 cps with a frequency tolerance of ±10%. Second, there are types called Frequency Doublers

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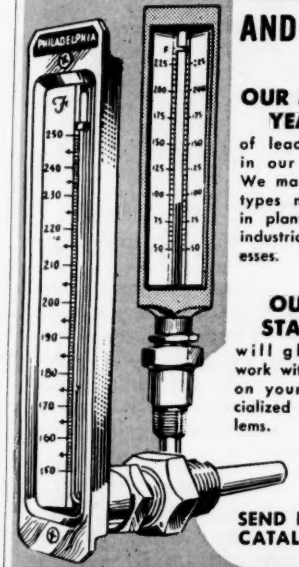

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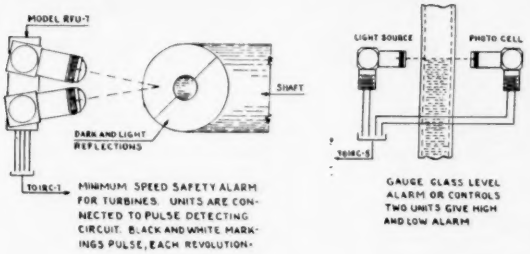
For more information circle **123** on inquiry card.

for operation at 60 and 50 cps with a tolerance of +½ cps where the contacts generate a 120 or 100 cps square wave respectively . . . (*From new 4-page Catalog 370F, Stevens-Arnold Inc., 7 Elkins St., South Boston 27, Mass.*)

For this literature circle **406** on inquiry card.

Electric Eyes

PHOTOCELL: Lead sulphide, cadmium sulphide or other type to suit purpose . . . . SPEED: Counters 600-1000 per min. Signals once each second; pulses up to 5000/sec. DELAY ACTION: Delay may be incorporated into unit to hold relay action 10 seconds (Model IRC 7A). Electronic relay can be furnished as a separate auxiliary to meet specifications. Standard timers may be included in control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TO IRC-5
GAUGE GLASS LEVEL ALARM OR CONTROLS TWO UNITS GIVE HIGH AND LOW ALARM

circuits between ESS relay and load. LIFE: Photo tubes should last a minimum of one year under normal conditions. Thyratron tubes should last six months or longer. Light source (at minimum voltage) should last six months. (*From new 16-page Bulletin 562, ESS Instrument Co., 96 S. Washington Ave., Bergenfield, N. J.*

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METER-RELAYS
FROM 0-5 MICROAMPERES-UP

Ruggedized-Sealed, Black Bakelite, or Clear Plastic Cases

D'Arsonval indicating meters with built-in locking contacts for sensitive and accurate control or alarm

TRIP POINT ADJUSTABLE to any point of scale arc. Sensitive to changes as little as 1%. One contact carried on moving pointer. The other on an adjustable pointer. When two pointers meet, contacts close and lock. Holding coil is wound directly over moving coil, locking action is electro-magnetic. Reset can be manual or automatic. Spring action in contacts kicks them apart forcefully.

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Ranges from 0-5 microamperes or 0-5 millivolts up, full scale. Temperature ranges from 0-300°F. (10 ohms external) have bimetal cold junction compensation. **Standard Contact Rating** 5 to 25 milliamperes DC. Can be built up to 100 milliamperes DC.

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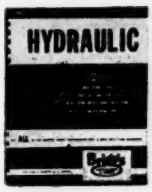

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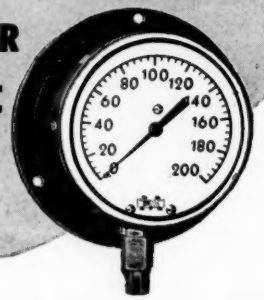

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Briefs—CONTINUED

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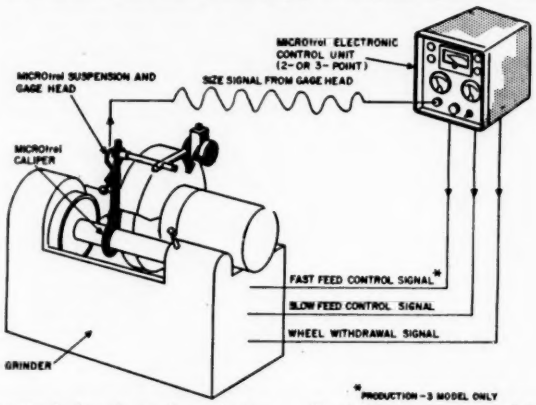
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FAST FEED CONTROL SIGNAL*
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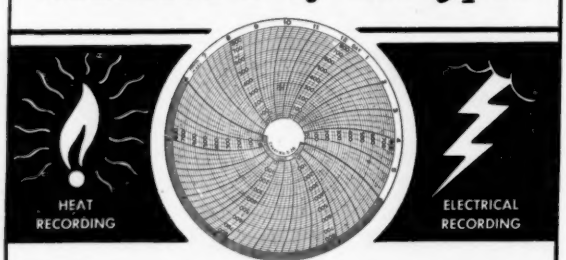
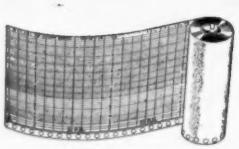
GRINDER
* PRODUCTION-3 MODEL ONLY

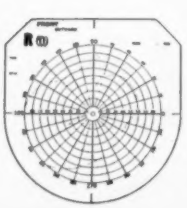
control signals to the grinder . . . Each of the three models includes electronic control unit, gage head, gaging caliper, caliper suspension and mounting . . . . (*From new 12-page Bulletin "Automatic Size Control," Industrial Products Dept., Airborne Instruments Lab., 160 Old Country Rd., Mineola, N. Y.*

For this literature circle **408** on inquiry card.

CHARTS of all types







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AC and DC VTVM's

A and E Series VTVM's are miniaturized, panel-mounting versions of the familiar laboratory instrument. They provide all the advantages of electronic measurement of AC voltages, and yet do not exceed the panel area required for standard panel meters. Standard ranges from 10 MV to 300 V AC. Accuracy: 2%.

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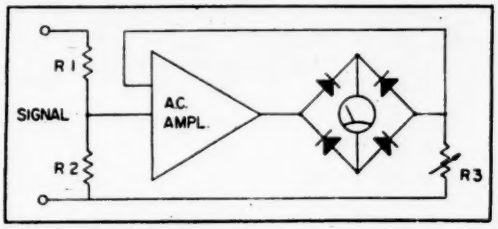

Models D and SD152 is a miniature, multi-range AC VTVM designed exclusively for panel mounting in military equipment. Typical applications include field testers as well as airborne and seaborne equipment. The distinguishing feature is signal isolation. Ranges: 10 MV to 300 V AC. Accuracy: 3%.

G Series is a ruggedized, miniature, panel-mounting DC VTVM for use in military applications. Accuracy: 2%. (*From new 32-page Catalog 57-110, Trio Laboratories, Inc., Seaford, L. I., N. Y.*)

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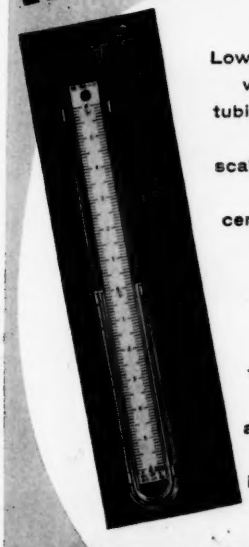
Dwyer FLEX-TUBE MANOMETERS
SERIES 1225



Low cost manometers of heavy walled unbreakable Butyrate tubing. Graduations and figures are silk-screened on fibre scale and protected by lacquer coating. Scale is on center line of tube, eliminating parallax errors, and is adjustable vertically for accurate zero adjustment.

Two groups: 1225 (conventional U-tube) and 1225U (U-tube with an inverted U at top for hose connection). Both groups in 12", 24" and 36" lengths. Write for Bulletin D-11.

F. W. DWYER MFG. CO.
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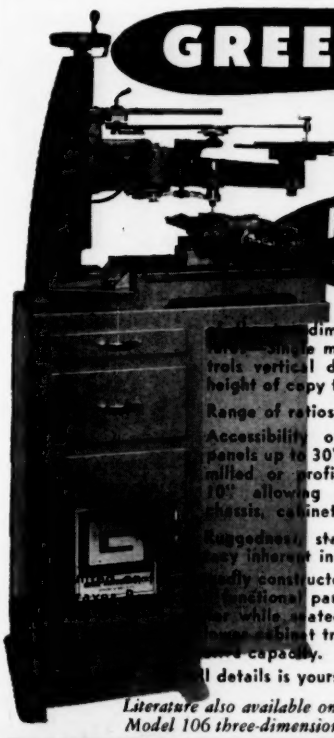
GREEN
Model D-2
Pantograph Engraver



Unique design dimensional Model D-2 features micrometer adjustment controls vertical depth of cut, and adjusts height of copy table and pantograph.

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Accessibility on three sides permitting panels up to 30" diameter to be engraved, milled or profiled. Vertical range over 10" allowing operations on complete chassis, cabinets or other bulky objects.

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Multi-circuit series data covered in Bulletin 4361.

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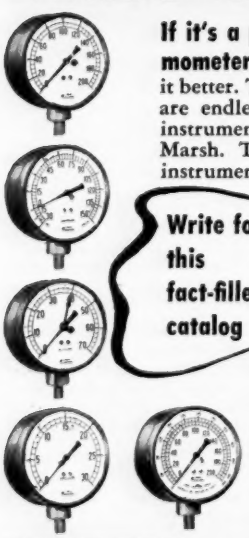

If it's a pressure gauge or dial thermometer, Marsh makes it . . . and makes it better. The types, ranges and case styles are endless. What is "special" to other instrument makers is often standard to Marsh. To know the scope of Marsh instruments—

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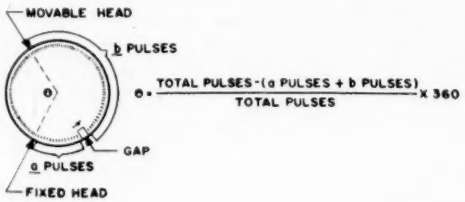
For more information circle **133** on inquiry card.

Briefs—CONTINUED

Shaft Position Quantizer

The Standard Austin Shaft Position Quantizer, Model 8, consists of a metal housing containing a synchronous motor that drives two rigidly coupled, engraved pulse-generating discs at the 3600-rpm speed of the motor. Each disc has 499 pulse-generating positions and a gap. A magnetic pickup head is mounted adjacent to each pulse-generating disc. One head is fixed and the other is coupled to the input shaft.



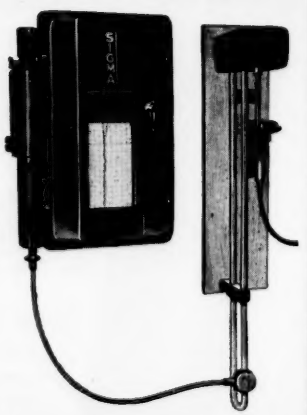
The Control Unit with a standard counter provides a convenient means of counting pulses from Quantizer and converting them to a binary, binary decimal, or other convenient output, proportional to the input shaft position . . . . The Control Unit, in addition to amplifying and shaping the pulses, provides for a frequency multiplication of eight times the 30-kc pulses from the Quantizer (500 pulse-generating positions x 3600 rpm or 60 rps) to provide, by interpolation, for a resolution of 1 part in 4000 . . . (*From new 4-page Brochure SDD, The Austin Co., 76 Ninth Ave., New York 11, N. Y.*)

For this literature circle **410** on inquiry card.

SIGMA CALORIMETERS

Accurately RECORD calorific values of gases from 80 B.t.u.'s and up

- **Provide reliable, trouble-free service**
- **Require little maintenance**
- **Simple in design**
- **Ruggedly built**
- **Free from continuously moving parts—except for chart drive**
- **Low in cost**



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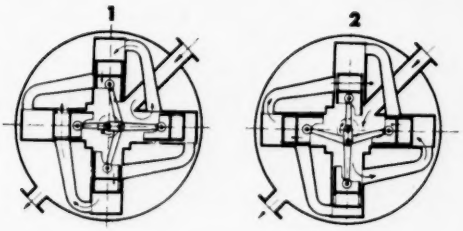
NATIONAL REPRESENTATIVES FOR SIGMA INSTRUMENT CO., ENGLAND

For more information circle **134** on inquiry card.

Positive Displacement Meters

The meter operates on the principle that the quantity of liquid displaced by each stroke of a piston is constant and the number of strokes may be integrated by a counting mechanism. In practice, the meter is fitted with four single-acting pistons arranged in such a way that each



piston controls the actions of the others—the pistons then act as sliding valves . . . No piston rings or glands are employed. The piston and cylinders are precision ground and honed to very close tolerances—sealing is accomplished along the entire surface of the pistons . . . Suitable for high viscosities to 500 ctks, high temperatures to 660°F; high pressures to 600 psi; capacities to 450 GPM (1" to 6" sizes); with accuracies guaranteed ¼% (1" Meter), ½% (2"—6" Meter) . . . (*From new 2-page Bulletin 400, Brooks Rotameter Co., Lansdale, Pa.*)

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Chip-proof
PLASTIC
LEGEND PLATES
engrave them yourself

Tough **GRAVOFLEX** blanks are laminated in sharp contrast colors. No need to keep large inventory—all sizes, varied colors available on short notice. Low-cost GRAVOFLEX legend plates stand *up* better, stand *out* better!

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you can DIAL your ADJUSTMENT on this AGASTAT® time/delay/relay

Frequent time adjustments are no problem with the dial head available on AGASTAT time/delay/relays. They provide a complete range of adjustment with 1 revolution of the dial. Dial markings permit easy calibration for accurate adjustment. And you can spot each of the 4 timing ranges quickly because they are color coded: blue from 30 seconds to 15 minutes; red from 10 seconds to 2 minutes; yellow from 0.1 to 10 seconds; white from 0.1 to 3 seconds.

Like all AGASTAT relays, units with dial heads are solenoid actuated, pneumatically timed. Each model is available with either dial head or needle valve adjustment. Where frequent readjustment of timing is necessary, dial head adjustment should be specified. For bulletin on all popular AGASTAT time delay relays, write to: Dept. A28-79.

AGA DIVISION

Elastic Stop Nut Corporation of America

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Pioneers in pneumatic timing

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SERVONIC

DO YOU NEED THE ADVANTAGES OF A POTENTIOMETER TYPE TRANSDUCER?

Servonic "Model H" pressure transducers retain system simplicity and high electrical output, but they offer these operational extras . . .

RUGGED	Vibration resistant — plus or minus 20 g's. — 100 to 2000 cps.
STAINLESS STEEL	Corrosion resistant — two corrosive fluids. — gauge and differential models.
LONG LIFE	Lubricated bearings and potentiometer. Sealed against the action of dust and humidity.
UNIQUE CONFIGURATION	Designed for "Stacking." Designed for easy access to electrical and fluid connectors.
OPERATIONAL RANGES	Temperature — minus 65°F. to plus 400°F. Pressure — 1000 to 10,000 psig. — 1000 to 10,000 psid.

SERVONIC INSTRUMENTS, INC. | 1145 So. Fair Oaks Pasadena 2, Cal. • RYan 1-1187

For more information circle **136** on inquiry card.

INSTRUMENTS and AUTOMATION — New Literature

For this literature or for more information on products reported or advertised in this issue, use handy card on page 1395.

AUTOMATION

PNEUMATIC CONTROL SYSTEM with "Speedomax G" for steel, chemical, petroleum and allied industries is described in a new 12-page Folder ND4(9).—Leeds & Northrup Co., 4934 Stenton Ave., Phila. 44, Pa.
Circle **412** on inquiry card.

SAFETY PANELS equipped with instruments which automatically guard gasoline engines with battery and/or magneto ignition are described in new 4-page Bulletin 18-705.—Stewart-Warner Corp., 1840 West Diversey Parkway, Chicago 14, Ill.
Circle **413** on inquiry card.

NUMERICAL POSITIONING CONTROL and detailed information on data input, director, and servo drive are contained in new 14-page Bulletin GET-2675.—General Electric Co., Schenectady 5, N. Y.
Circle **414** on inquiry card.

BLOWER CONTROL in steel mill (parallel, split-wind) is the subject of new 4-page bulletin.—Askania Regulator Co., Chicago 11, Ill.
Circle **415** on inquiry card.

STACK CONTROLLERS and New Scanning Control Stations with application and operating data are described in new 20-page Bulletin 5013.—Moore Products Co., Phila. 24, Pa.
Circle **416** on inquiry card.

CONTROL INSTRUMENTATION, including maker's transistorized Instrument-Translator control system, "Type 67;" a single channel control system; and frictionless torque pickups which do not employ brushes or slip rings are described in three new 4-page brochures.—Crescent Engineering & Research Co., 5440 N. Peck Rd., El Monte, Calif.
Circle **417** on inquiry card.

AUTOMATIC CONTROL equipment including switching and temperature controllers, photoelectric detector proximity detector, light beam projector, etc., are described and specified in new 16-page brochure.—Autron Engineering, Inc., 1254 W. 6th St., Los Angeles 17, Calif.
Circle **418** on inquiry card.

MOTORS, SERVOS

GEARED MOTORS, Type TYAZ-CE, for use in servo-mechanisms, voltage regulators, combustion and industrial controls, are described in new 4-page Catalog GR2.—Barber-Colman Co., Small Motors Div., 1400 Rock St., Rockford, Ill.
Circle **419** on inquiry card.

CARBON BRUSHES, presented in new 34-page catalog, are designed for electric tool motors.—Ohio Carbon Co., Dept. 186, 12508 Berea Rd., Cleveland 11, Ohio.
Circle **420** on inquiry card.

SERVO COMPONENTS, including potentiometers, servo motors, synchros, servo-kit, servo speed-torque unit, servo amplifiers, and precision switches, are described in new 4-page bulletin.—The Servo Systems Co., 55 Meeker Ave., Newark 12, N. J.
Circle **421** on inquiry card.

VALVES, ACTUATORS

VALVE ACTUATORS, Westinghouse Air Brake type, for maker's screwed-gland type, wrench-operated valves are tabulated in new 4-page Bulletin V-604.—Rockwell Mfg. Co., 400 N. Lexington Ave., Pittsburgh 8, Pa.
Circle **422** on inquiry card.

SOLENOID VALVES of stainless steel, "Type GX," with teflon seals for corrosive gases and liquids are described and specified in new 2-page bulletin.—J. D. Gould Co., 4707 Massachusetts Ave., Indianapolis 18, Ind.
Circle **423** on inquiry card.

AIR CONTROL VALVES, including sliding sleeve, single plunger, "O"-type, "B"-type and hydraulic valves, are contained in new 12-page Bulletin 571.—C. B. Hunt & Son, Inc., Salem, Ohio.
Circle **424** on inquiry card.

RELIEF and back pressure valves for chemical applications, with specifications of four standard sizes, ¼, ½, ¾ and 1" are the subject of new 4-page Bulletin 357.—Milton Roy Co., 1300 East Mermaid Lane, Phila. 18, Pa.
Circle **425** on inquiry card.

DIAPHRAGM CONTROL VALVES, direct acting, reverse acting and three way, are described in new 4-page Bulletin V-8.—Seely Instrument Co., Inc., Niagara Falls, N. Y.
Circle **426** on inquiry card.

ACTUATORS, electrically controlled, for plug or gate valves, bulkhead gates, etc. are described in 8-page Catalog T-82.—Harvill Corp., 6251 W. Century Blvd., Los Angeles 45, Calif.
Circle **427** on inquiry card.

PRESSURE REDUCING VALVES, for inlet pressures up to 1500 psi at temperatures of 875°F are described in new 6-page Folder BV-5-55.—Atlas Valve Co., Newark 5, N. J.
Circle **428** on inquiry card.

BALL VALVES of stainless steel are described and specified in new 4-page Bulletin 5M-3-57.—Rockford Sprinkler Co., 38 Harlow St., Worcester 5, Mass.
Circle **429** on inquiry card.

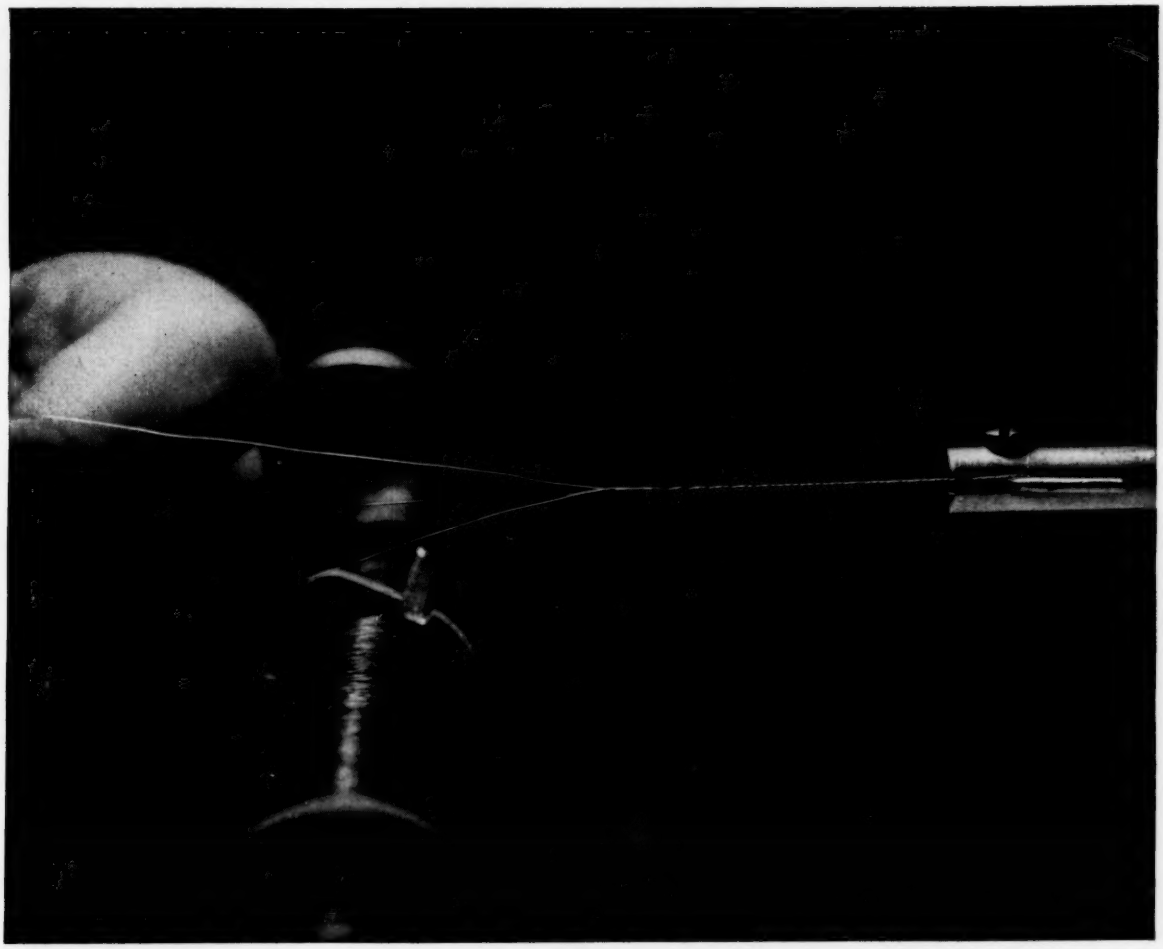
MICRO NEEDLE VALVE and micro globes valves for corrosive service are described in 6-page Catalog C-1056.—Chemtrol Corp., 1513 W. El Segundo Blvd., Compton, Calif.
Circle **430** on inquiry card.

QUICK-DUMP VALVES, with hand lever for operating double acting cylinder, or with electro-magnetic armature, are described in new 2-page bulletin.—Humphrey Products Div., General Gas Light Co., Kalamazoo, Mich.
Circle **431** on inquiry card.

REGULATORS for pressure and temperature; solenoid, diaphragm, motorized and float valves; pressure reducing, flow control, safety and relief valves are covered in the new 8-page Catalog 57.—O. C. Keckley Co., 3402 Cleveland St., Skokie, Ill.
Circle **432** on inquiry card.

TEMPERATURE

THERMOCOUPLE and extension wire covered with bonded staple fiberglass yarns is discussed in new Bulletin



Solderless splice solves problem of open coil windings

STANDARDS THAT DETERMINE RELAY QUALITY /

trouble-free coil windings

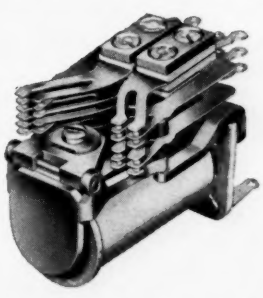
Solderless splice ends failures two ways

The two chief causes of relay coil windings going open in service are: (1) electrolysis, and (2) breaking at the terminal. Automatic Electric prevents these difficulties with a winding termination technique that is vitally different.

We do not attach coil endings of fine wire directly to the terminals. Instead, we carefully strip the insulating enamel from several inches of the coil endings and tightly twist this length of wire with strands of bare tinned copper wire. This strong solderless splice is then insulated with a special film sheet.

Because we make terminal connections over a long section of stranded wire, electrolysis has no single point to attack. And this flexible connection will never snap under temperature extremes or other stress-producing factors.

In every step of relay design and manufacture, we take extra pains to prevent trouble before it starts.



Class "E" Relay *reduces the best of the Class B features to a minimum of space and weight. Write for Relay Highlight #14. Automatic Electric Sales Corporation, Northlake, Illinois.* In Canada: *Automatic Electric Sales (Canada) Ltd., Toronto.* Offices in principal cities.

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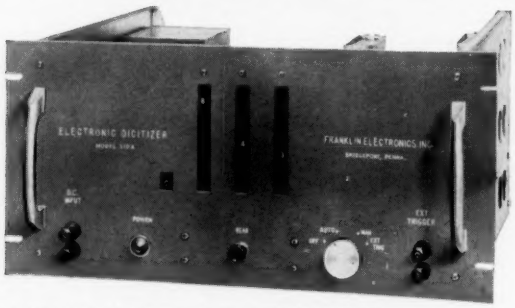
NEW ALL ELECTRONIC Digitizer

Provides FAST, Accurate Readings at LOW COST!!



FRANKLIN MODEL 310 A DIGITIZER
IDEAL FOR PRECISION VOLTAGE MEASURING
IN LABORATORY OR ON PRODUCTION LINE

This ALL Electronic digitizer has been developed as a multipurpose instrument which can be used as an analog to digital converter, voltmeter, or data reduction element. Measuring voltages from 000.0-120.0 volts it provides accuracy of 0.1% of full scale and speed of 60 readings per second, automatically or on command . . . heretofore unobtainable at this low cost. Coded outputs of each significant figure in the visual readout provide a signal source to operate matrices, printers, punches, or categorizing equipment.

FOR REDUCING DATA FROM

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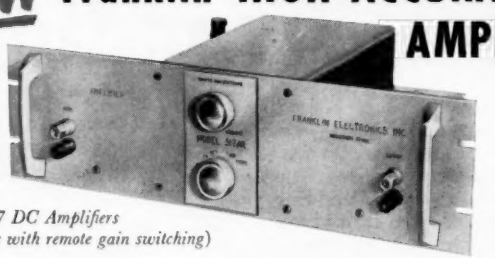
- *Thermocouples*
- *Strain Gauges*
- *Other Transducers*

FOR MEASURING

- *Strain*
- *Pressure*
- *Temperature*
- *Voltages*
- *Motion*

NEW Franklin HIGH-ACCURACY DC AMPLIFIERS



Model 317 DC Amplifiers
(Available with remote gain switching)

Franklin's line of Model 317 DC Amplifiers is especially designed to convert very low voltages (microvolt ranges) to levels useable by the Model 310 A Digitizer. Standard gain accuracy is 0.05%. Power supplied from Model 310 A.

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Electronic & Nuclear Development & Manufacturing

For more information circle **138** on inquiry card.

NEW LITERATURE

1200-1.—Thermocouple assemblies of Chromel-Alumel, and Iron-Constantan are illustrated and described in a new 4-page Bulletin TA-4-57.—Claud S. Gordon Co., 3000 S. Wallace St., Chicago 16, Ill.
Circle **433** on inquiry card.

THERMOWELLS made of bar stock or built-up are described in new 4-page Bulletin D-1.—Thermo Electric Co., Inc., Saddle Brook, N. J.
Circle **434** on inquiry card.

THERMOCOUPLE TUBING. including constantan, chromel-P, alumel, and ingot iron, is the subject of new 3-page Memo 118.—Superior Tube Co., 1566 Germantown Ave., Norristown, Pa.
Circle **435** on inquiry card.

ELECTRIC THERMOSTATS are described in new 4-page bulletins: RT-802 (Model EA4), spst, is for air conditioning equipment; RT-807 (Model F1), spdt, is for constant heat ovens, etc; RT-808 (Model F2), sp-two circuit, is for heavy liquids; RT-810 (Models B10 and B20), sp-slow make-and-break, is for close temperature differential applications.—Robertshaw-Fulton Controls Co., 110 East Otterman St., Greensburg, Pa.
Circle **436** on inquiry card.

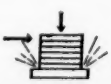
FLOW, LEVEL

TURBINE FLOW METERS, for precise measurement of liquid flows at rates from one gpm to more than 2500 gpm, are covered in new 8-page Catalog 10C150.—Fischer & Porter Co., 75 Jacksonville Rd., Hatboro, Pa.
Circle **437** on inquiry card.

ILLUMINATOR for liquid level gage which is explosion-proof and provides greater illumination and simplified installation.—Jerguson Gage & Valve Co., 80 Adams St., Burlington, Mass.
Circle **438** on inquiry card.

IRRIGATION METERS, including maker's line of low pressure line meters, open flow meters, irrimeters, meter-valves and recording instruments, are the subject of 25-page Bulletin 500.—Sparling Meter Co., Inc., 225 N. Temple City Blvd., El Monte, Calif.
Circle **439** on inquiry card.

UTILITY PUMPS with helical screw motor are presented in new 4-page Bulletin CP3481.—Continental Pump Co., 1027 Vandeventer Ave., St. Louis 10, Miss.
Circle **440** on inquiry card.



PRESSURE, WEIGHT, FORCE

PRESSURE METER, "Press-I-Cell," for precise measurement of absolute, gage, or differential pressure is described in new 12-page Catalog 11-102.—Fischer & Porter Co., 99 Jacksonville Rd., Hatboro, Pa.
Circle **441** on inquiry card.

PRESSURE TRANSDUCERS, piezoelectric, and a discussion of their linearity, dynamic range, effects of aging, and temperature problems are the subject of new 2-page Technical Note 2.—Atlantic Research Corp., Alexandria, Va.

Circle **442** on inquiry card.

MERCURIAL BAROMETERS and vacuum gages, vacuum pump gages, and absolute pressure gages are illustrated and described in new 4-page Bulletin D-2.—Precision Thermometer & Instrument Co., 1434 Brandywine St., Phila. 30, Pa.

Circle **443** on inquiry card.

BELT GRAVIMETRIC FEEDER Hi-Weigh Model 37-20 for continuously weighing and feeding dry materials at high rates is described in new 4-page Bulletin 35-N62.—Omega Machine Co., Div. of B-I-F Industries, Inc., Providence 1, R. I.

Circle **444** on inquiry card.

SERVOMANOMETERS for precise pressure measurement and instrument calibration are described in new 8-page Bulletin 500.—Exactel Instrument Co., 5545 Eva Ave., Los Altos, Calif.

Circle **445** on inquiry card.

FORCE control switches for tensile and compression loads are detailed and specified in 2-page Bulletin 49E.—W. C. Dillon & Co., Inc., 14620 Keswick St., Van Nuys, Calif.

Circle **446** on inquiry card.

COMBUSTION, AIR

COMBUSTION CONTROLS, including automatic draft control instruments and actuators; solenoid, diaphragm and motor-operated valves for oil, gas, steam and water; time switches, relays and oil burner primary controls, are covered in new 36-page Catalog 608.215.—General Controls Co., 801 Allen Ave., Glendale 1, Calif.

Circle **447** on inquiry card.

AIR CONDITIONING systems, "Kathabar," which provide continuous supply of air at conditions anywhere below 32°F dry bulb and dew point, are discussed in new 4-page bulletin.—Surface Combustion Corp., 2380 Dorr St., Toledo 1, Ohio.

Circle **448** on inquiry card.

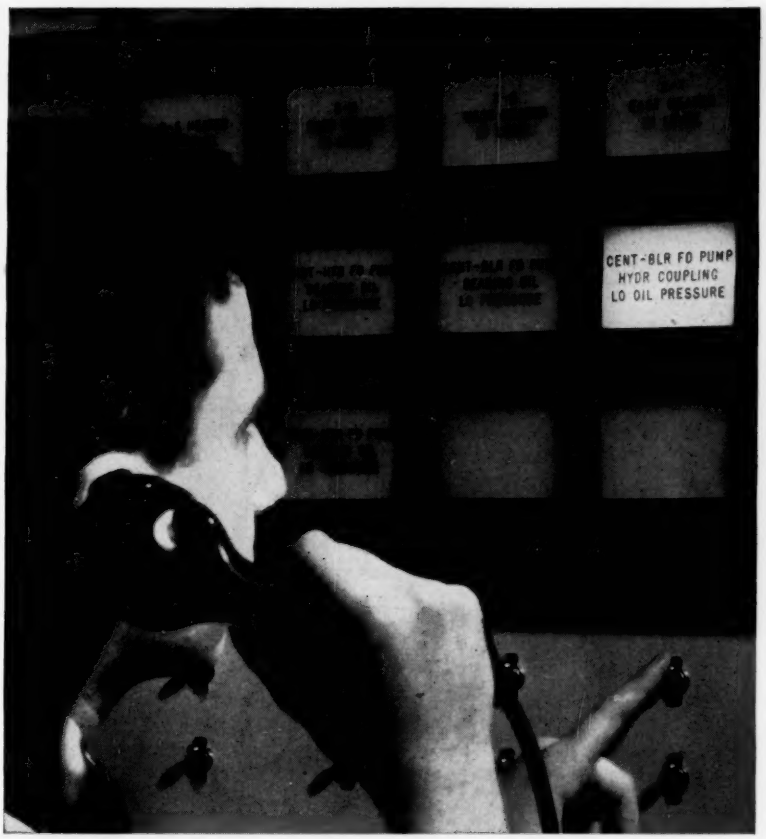
LABORATORY, ANALYTICAL

BURETS for direct-digital readings are described in new 4-page Bulletin 2286.—American Instrument Co., Inc., Silver Spring, Md.

Circle **449** on inquiry card.

LABORATORY INSTRUMENTATION, including two new pH meters ("Zeromatic" and "Pocket"), and infrared spectrophotometer news are the subjects of new 12-page "Beckman Bulletin No. 19" Beckman Instruments, Inc., Fullerton, Calif.

Circle **450** on inquiry card.



Panalarm Annunciator pinpoints process "off-normals"

In the process industries and among users of automatic machinery, trouble is minimized when it's caught early. That's the purpose of the Panalarm Annunciator System—a continuous monitor of your process.

One typical adaptation of the modular Panalarm system is engineered to differentiate between the first "off-normal" and subsequent "off-normals" caused by the first. This feature allows instantaneous recognition of the prime source of trouble in a "chain reaction."

Another adaptation is designed specifically for motor start-up and shut-down. It has also been successfully adapted for supervisory control, pump control and programming.

Your Panalarm sales engineer will be happy to make a survey of your requirements to determine whether a Panalarm system can aid productivity and safety in your process. For electrical and mechanical data on standard systems, request Catalog 100B on your letterhead.

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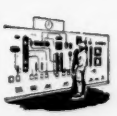
Graphic Panels, Control Centers

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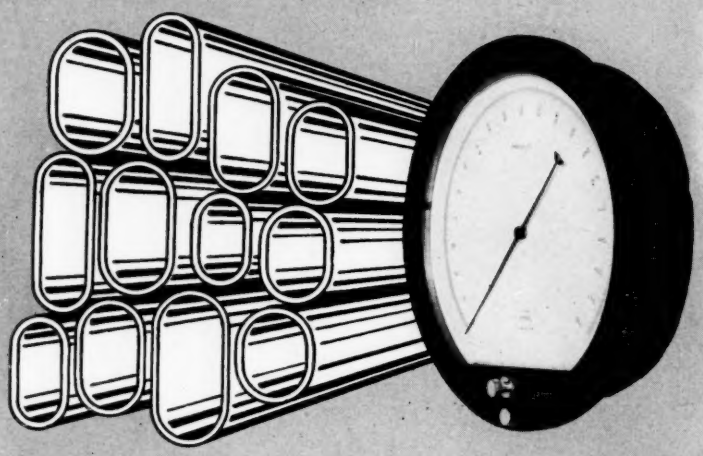
HEISE GAUGES

Designed for Dependability

Does your high pressure gauge application require a scientifically designed Bourdon Tube?



Where highly accurate results are required design considerations such as the depth – width ratio of the Bourdon Tube section are of paramount importance.

Extreme fiber stress resulting from improper design of the tube may render an apparently good instrument completely undependable.

At the Heise Laboratories, mathematical solutions for determining the size and shape of Bourdon Tubes for specific use are augmented by years of research and tests on various types of tubes to assure correct stress distribution.

Heise Bourdon Tubes are heat treated by scientific methods to guarantee that each tube will be metallurgically sound for its application. The precision heat treatment of thin walled tubing without distortion has been made possible by equipment and technique developed by Heise Laboratories.

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Pressure Ranges 15 to 20,000 P.S.I. Dial Sizes 8½"—12"—16"

Prices from $151.60. **DELIVERY WITHIN 30 DAYS.**

HEISE BOURDON TUBE COMPANY, INC.

BROOK ROAD, NEWTOWN, CONNECTICUT, U.S.A.

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NEW LITERATURE

DETECTOR KIT for TDI (toluene diisocyanate) and TDI-urea vapors in air in plants manufacturing polyurethane plastics, is described in 2-page Bulletin 0811-4.—Mine Safety Appliances Co., Pittsburgh, Pa.

Circle **451** on inquiry card.

GLASSWARE SYSTEMS which are interchangeable, suitable for distillation, reflux, saponification, reaction in vacuum, filtration, gas evolution, etc. are the subject of new 4-page Catalog 3MU.—Stoppers made of teflon, available in 24/40, 29/42, 34/45 and 45/50 taper are described and priced in new 2-page leaflet.—Arthur F. Smith Co., 311 Alexander St., Rochester 3, N. Y.

Circle **452** on inquiry card.

EXTRACTOR of solvents from solid materials is described in new 2-page leaflet.—Roweg Apparatus Co., Ledgewood, N. J.

Circle **453** on inquiry card.

LIQUID EVAPORATOR ("Epiradiator") which operates by remote heat radiation without any contact with the liquid, is detailed in new 4-page folder.—Quartz Products Corp., Box 628, Plainfield, N. J.

Circle **454** on inquiry card.

LABORATORY SUPPLIES of polyethylene, including tanks, bags, bottle stoppers, stirring paddle, etc. are shown in new 2-page folder.—Laboratory Supplies, Inc., 81 Reade St., New York 7, N. Y.

Circle **455** on inquiry card.

RESEARCH EQUIPMENT, including "Freeze-Mobile," a portable unit for freeze-drying; histological, biological, infra-red and roto-freeze units, a homogenizer and accessories are shown and specified in new 18-page catalog. —Will Corp., Rochester 3, N. Y.

Circle **456** on inquiry card.

BATH COOLER AND CONTROL UNIT are contained in two new 2-page bulletins.—Arthur S. LaPine & Co., 6001 S. Knox Ave., Chicago 29, Ill.

Circle **457** on inquiry card.

LABORATORY INSTRUMENTS for various tests are subjects of seven new issues of "Gardner Newsletter, Vol. 4": (1) 4-page No. 22 describes an automatic multipurpose reflectometer; (2) 20-page No. 23 covers a tester for hardness and drying time of coating materials; (3) 2-page No. 24 contains paint flaw detectors; (4) 2-page No. 25 deals with a brightness and reflectance meter; (5) 2-page No. 26 has a precision reflectometer and paper brightness meter for its subject; (6) 2-page No. 27 specifies the Baker-Patton pigment-settling gage; and (7) in 4-page No. 28 there is a description of the "Coverall" impact tester for coatings.—Gardner Laboratory, Inc. Box 5728, Bethesda 14, Md.

Circle **458** on inquiry card.

NUCLEONICS

NUCLEONIC EQUIPMENT, including maker's 1024-channel neutron time-of-flight analyzer, two new thermal neutron counters, the automatic dead-time correction circuit of maker's 256-channel analyzer and "Mark II," a fast-slow neutron survey meter, are described in 4-page bulletin, vol. 4. No. 2 of "RCL Counter."—Radiation Counter Labs., Inc., Nucleonic Park, Skokie, Ill.

Circle **459** on inquiry card.

NUCLEAR SHIELDING products, including maker's zinc bromide, water filled and lead glass protective windows, portable shields, portable lead containers, etc. are discussed in new 8-page Catalog 57.—Ameray Corp., Nuclear Products Div., Rt. 46, Kenvil, N. J.

Circle **460** on inquiry card.

RADIOACTIVITY MONITOR. New 6-page Bulletin AM-57 describes monitoring systems for detection, recording and warning of airborne particulate radioactivity.—Nuclear Measurements Corp., 2460 North Arlington Ave., Indianapolis 18, Ind.

Circle **461** on inquiry card.

MEDICAL

MASS SPECTROMETER, Type 21-611, for medical, university, or industrial applications is described in new 6-page Folder 1843.—Consolidated Electrodynamics Corp., 300 N. Sierra Madre Villa, Pasadena, Calif.

Circle **462** on inquiry card.

CARDIAC RESUSCITATION instrumentation, maker's external-internal defibrillator used in conjunction with "Morris Clinical Pacemaker" is the subject of 2-page Form EID357.—Levinthal Electronic Products, Inc., 905 Stanford Industrial Park, Palo Alto, Calif.

Circle **463** on inquiry card.

OPTICAL

PRECISION OPTICS, including infrared systems components fabricated from grown silicon crystals are described in two new Bulletins 0-104 and 0-105.—Texas Instruments Inc., Optics Div., 104 East Foothill Blvd., Monrovia, Calif.

Circle **464** on inquiry card.

PHOTOGRAPHIC EQUIPMENT, including new enlargers, dryers, cameras, adapters, lighting fixtures, movie equipment, and related devices, are covered in new 104-page Catalog 457M.—Burke & James, Inc., 321 S. Wabash Ave., Chicago 4, Ill.

Circle **465** on inquiry card.

OPTICAL INSTRUMENTS for science teaching are described in new 6-page Catalog E-152.—Bausch & Lomb Optical Co., Rochester 2, N. Y.

Circle **466** on inquiry card.

CAMERA, maker's 1957 35-mm automatic "Exakta IIa," a single lens reflex model, is presented in new 8-page brochure.—Exakta Camera Co., 705 Bronx River Rd., Bronxville 8, N. Y.

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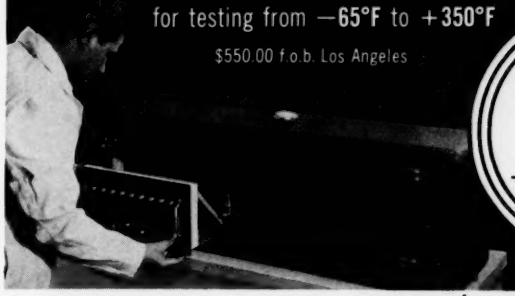
the most versatile temperature test chamber for laboratory or production line...

for testing from −65°F to +350°F

$550.00 f.o.b. Los Angeles



Statham MODEL TC-2A TEMPERATURE TEST CHAMBER

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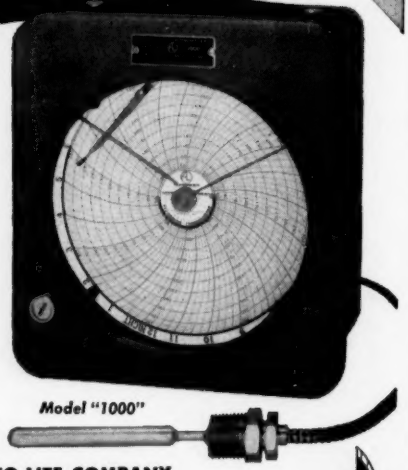

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For more information circle **145** on inquiry card.

NEW LITERATURE

COLOR CONTROL instrument, "Agtron," which assigns a numerical reading directly to a product by comparing it to the appearance standard which the manufacturer desires to maintain, is discussed in 4-page Bulletin 501.—Magnuson Engineers, Inc., 509 Emory St., San Jose, Calif.

Circle **468** on inquiry card.

DATA HANDLING

ELECTRONIC DATA PROCESSING system "Alwac 800" is described in a new 4-page bulletin.—Alwac Corp., 1340 South Cerise Ave., Hawthorne, Calif.

Circle **469** on inquiry card.

DATA PROCESSING SYSTEMS and their applications are the subject of six new brochures: (1) No. 4-05-020 (12 pages)—payroll processing; (2) No. 4-05-010, (4 pages)—invoice billing; (3) No. 5-01-110 (4 pages)—parts inventory controlling; (4) No. 4-05-030 (8 pages)—accounts payable; (5) No. 4-04-020 (8 pages)—utility billing; and (6) No. 4-02-12 (6 pages)—life insurance.—Electro Data Div., Burroughs Corp., 460 Sierra Madre Villa, Pasadena, Calif.

Circle **470** on inquiry card.

PUNCHED CARD SENSOR that simultaneously senses the entire card and is adaptable to any combination of 540 switching operations, is described in new 2-page bulletin.—Metron Corp., 8 Coryell St., Lambertyville, N. J.

Circle **471** on inquiry card.

TELETYPEWRITER terminal system which handles codes at 60, 75 or 100 words-per-minute, for sixteen channels, is the subject of new 12-page brochure.—Rixon Electronics Inc., 2414 Reedie Dr., Silver Spring, Md.

Circle **472** on inquiry card.

NOISE in magnetic tape recordings, including frequency modulation noise, drop-out noise, etc. is the subject of new 5-page Bulletin 34.—Minnesota Mining and Manufacturing Co., 900 Bush St., St. Paul 6, Minn.

Circle **473** on inquiry card.

D-C GATING SYSTEM for fast and accurate multiplexing of critical analogue signals, is outlined in 2-page Bulletin 11-56.—Dynamics Instrumentation Co., S. Pasadena, Calif.

Circle **474** on inquiry card.

RECORDERS

RECORDING SYSTEM, PAR-1, consisting of oscillograph and galvanometer, providing an accurate method of obtaining data recorded on magnetic tape is described in 2-page data sheet. Oscillographs, new Models 601 and 602, that require no record developing or processing are described in new 4-page bulletin.—Midwestern Instruments, 41st and Sheridan Rd., Tulsa, Okla.

Circle **475** on inquiry card.

WATER VAPOR RECORDER for continuous measurement of low concentrations of water vapor in air or gases, for process industries and gas pipelines is presented in new 8-page Bulletin 0714-1.—Mine Safety Appliances Co., 201 N. Braddock Ave., Pittsburgh 8, Pa.

Circle **476** on inquiry card.

INKLESS RECORDER for multi-channel time recording is the subject of 4-page Brochure ROS-600—Maker's transistorized contact meter controller Model "MR" is detailed in 4-page Brochure MR-800.—Larson Instrument Co., 24 Orchard St., Tarrytown, N. Y.

Circle **477** on inquiry card.

GAGING, TESTING

CORONA TEST SET for non-destructive evaluation of electrical insulation is described in a new 8-page Bulletin 66.—James G. Biddle Co., 1316 Arch St., Phila. 7, Pa.

Circle **478** on inquiry card.

OIL TESTING KIT to determine harmful contaminants is described in new 4-page "Newsletter" (special).—Gardner Lab., Inc., Bethesda 14, Md.

Circle **479** on inquiry card.

UNIVERSAL RELAY TESTER, including specifications (electrical and special characteristics) is presented in new 4-page brochure.—The Magnavox Co., Department N.P., Fort Wayne 4, Ind.

Circle **480** on inquiry card.

DUCTILITY TESTING machine, "Model D," for material before drawing, is described in new 2-page Form D-856.—Steel City Testing Machines, Inc., 8817 Lyndon Ave., Detroit 38, Mich.

Circle **481** on inquiry card.

LUBRICANT TESTING machine, Model LFW-1, including description of machine's operation and revised specifications list, is covered in new 2-page Bulletin 106.—The Alpha Molykote Corp., 65 Harvard Ave., Stamford, Conn.

Circle **482** on inquiry card.

TEST CHAMBERS for environmental testing, metal treating, storage and preservation of chemicals and biologicals, research and production are discussed in new 78-page folder. Includes 4 tables (temperature conversion, percent of saturation, standard atmosphere data, and relative humidity.)—Environmental Equipment Corp., Brooklyn, N. Y.

Circle **483** on inquiry card.

FILTRATION PROCESS ANALYZER, "dynateq" R-8, designed to measure and record automatically weight and weight rate in the plugging value of viscose, is the subject of 6-page Report 66-R8.—Dynamics Research Associates, Div. of Universal Match Corp., Box 5841, Ferguson 21, Miss.

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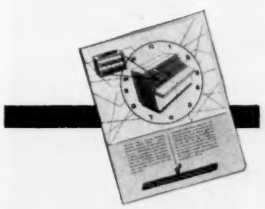

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NEW LITERATURE

HYPOTS, mobile units, for d-c high-potential testing of dielectric strength, h-v insulation resistance, dielectric absorption of cable generators, transformers, bushings, capacitors, motors, and insulation materials are described in new 8-page Bulletin 5-11.—Associated Research, Inc., 3758 West Belmont Ave., Chicago 18, Ill.

Circle **485** on inquiry card.

NON-DESTRUCTIVE TESTING techniques for metals and other materials are the subject of new 8-page Bulletin 57.—J. W. Dice Co., Englewood, N. J.

Circle **486** on inquiry card.

GAGE PLUGS for comparators ground to order, can be selected from new Select-Aire Wall chart.—Pratt & Whitney Co. Inc., West Hartford 1, Conn.

Circle **487** on inquiry card.

GAGE LABORATORY instrumentation planning; how individual plants may set up their own individual gage laboratories to meet requirements for closer and more convenient control of parts measurement standards, is the subject of new 19-page Catalog IN-57.—Sheffield Corp., Dayton 1, Ohio.

Circle **488** on inquiry card.

FIBER VIBRASCOPE, a test instrument for measuring single-fiber or strand linear density (or denier) is described in Bulletin 1157.—G. F. Bush Associates, Box 175, Princeton, N. J.

Circle **489** on inquiry card.

TUBE TESTERS for electronic instruments, including "Model GCT-5", "Model 107", "Model FB-4" flyback circuit and inductance analyzer, and "Model FP-1" filament continuity checker are described in new 12-page Folder 6374-457.—Seco Mfg. Co., 5015 Penn Ave., Minneapolis 19, Minn.

Circle **490** on inquiry card.

ELECTRICAL, ELECTRONIC INSTRUMENTS

ELECTRONIC INSTRUMENTS, comprising digital data systems, r-f laboratory test instrumentation, and nuclear instruments are contained in new 6-page Short Form Catalog 58-100.—BJ Electronics, Borg-Warner Corp., Santa Ana, Calif.

Circle **491** on inquiry card.

SERVOMOTOR-RATE GENERATOR, Model 18 MG 690/660, in unitized housing, rotating on common shaft, is described in the new 2-page Data Sheet 866.—Helipot Technical Information Service, Newport Beach, Calif.

Circle **492** on inquiry card.

ELECTRONIC GALVANOMETER, Model 204A, a combination DC null detector, linear deflection indicator, microvoltmeter, micro-microammeter and low level DC amplifier is covered in

new 2-page Bulletin 14-3.—KinTel (Kay Lab), 5725 Kearny Villa Road, San Diego, Calif.

Circle **493** on inquiry card.

ELECTRONIC COUNTERS, including maker's decade, binary, and preset scalers, are described in new 4-page Bulletin 1700.—Laboratory for Electronics, Inc., 75 Pitts St., Boston 14, Mass.

Circle **494** on inquiry card.

TRANSFORMERS, Type RA, portable, with different primary-range values from 0.5 to 200 amps, are the subject of 4-page Bulletin 229.—Knopp Inc., 4224 Holden St., Oakland 8, Calif.

Circle **495** on inquiry card.

DC VOLTMETER, helical potentiometric with wide range, is detailed in the new 2-page bulletin.—Paul Industries, P. O. Box 3474, Glendale, Calif.

Circle **496** on inquiry card.

X-RAY GONIOMETER for quartz crystal orientation is described in 6-page bulletin of British manufacturer.—Jarrell-Ash Co., 26 Farwell St., Newtonville 60, Mass.

Circle **497** on inquiry card.

ELECTRICAL MEASURMENTS ADAPTER, "Millivac Poly-Functionist" type CM-21, a combined voltage divider, shunt box, and Wheatstone bridge is described in new 4-page Bulletin V-802.—Millivac Instrument Corp., P. O. Box 997, Schenectady, N. Y.

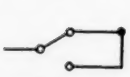
Circle **498** on inquiry card.

METAL DETECTOR, "Private Eye model 711," an electronic device for detecting hidden, submerged and buried metals and minerals, is described in new 2-page bulletin.—The Radiac Co., Inc., 489 5th Ave., New York 17, N. Y.

Circle **499** on inquiry card.

VARIABLE TRANSFORMER, portable, Type 2PF10, for low wattage, is described in new 2-page Data Sheet SE-L25714; 2-page Bulletin SE-L3574 describes temperature limited diode type 1236C, designed as a RMS detector for a-c voltage and current stabilizers.—The Superior Electric Co., Bristol, Conn.

Circle **500** on inquiry card.



SWITCHES, RELAYS

MERCURY SWITCHES for microvolt-milliamp circuits are shown on Data Sheet 114; mercury switches for pulse circuits are contained in Data Sheet 118; maker's "Space-Saver" lighted pushbutton switch is described in Data Sheet 123; magnetic proximity switch is subject of Data Sheet 130.—Micro Switch, Div. of Minneapolis-Honeywell Regulator Co., Freeport, Ill.

Circle **501** on inquiry card.

MINIATURE PHOTOELECTRIC RELAYS without tubes or transistors are described in new 2-page bulletin.—Tri-Tronics Co., 2607 St. Charles Rd., Bellwood, Ill.

Circle **502** on inquiry card.

Flutter Effects of Wind Tunnel Model

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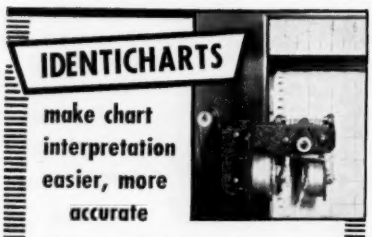

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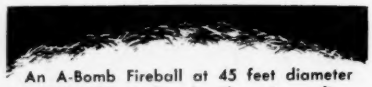

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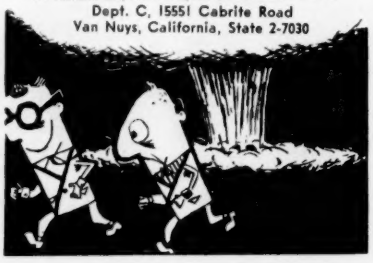


NEW LITERATURE

RELAYS, maker's "IMP" (interchangeable multiple pole) and "FMP" (fixed multiple pole) heavy duty models, are discussed in new 8-page booklet.—The Arrow-Hart & Hegeman Electric Co., 103 Hawthorne St., Hartford 6, Conn.
Circle **503** on inquiry card.

METER RELAYS. New 12-page Bulletin 104 contains information on miniaturized automatic control with meter-relays. Contains circuit diagrams.—Assembly Products, Inc., Chesterland 9, Ohio.
Circle **504** on inquiry card.

LIMIT SWITCHES. New 8-page Bulletin 956 pictures and describes maker's "Loxswitch" Machine tool limit switches.—R. B. Denison Mfg. Co., 102 St. Clair Ave., N. W., Cleveland 13, Ohio
Circle **505** on inquiry card.

RESISTORS, POTENTIOMETERS

RESISTORS AND POTENTIOMETERS are discussed in new 28-page Catalog 57.—Clarostat Mfg. Co., Inc., Dover, New Hampshire.
Circle **506** on inquiry card.

RESISTORS which feature thermal matching of core, terminals, wire and vitreous enamel coating are the subject of new 2-page bulletin.—Harwick, Hindle, Inc., 40 Hermon St., Newark 5, N. J.
Circle **507** on inquiry card.

ELECTRICAL, ELECTRONIC COMPONENTS

ELECTRONIC COMPONENTS are covered in folder containing (1) 10-page Catalog 54 on circuitry structures including socket turrets, socket strips and plug-in nuts; (2) new 8-page bulletin on strip turret modular system for electronic circuitry; (3) two 2-page bulletins Section IX and No. 55 describe experimenter's chassis kits 20X, 21X and 22X; (4) new 2-page Bulletin 51 which covers zip terminals; (5) new 2-page bulletins cover tube socket test adapters, etc. includes also 4-page price list.—Vector Electronic Co., 3352 San Fernando Rd., Los Angeles 65, Calif.
Circle **508** on inquiry card.

SHIELDED COIL FORMS are presented in new 2-page Bulletin 29.—Cambridge Thermionic Corp., 445 Concord Ave., Cambridge 38, Mass.
Circle **509** on inquiry card.

LAMINATIONS for transformers, transistors, and other miniature size applications are discussed on card, to which samples of makers EE 28-29 standard laminations are attached.—Magnetics, Inc., Butler, Pa.
Circle **510** on inquiry card.

CAPACITOR CHART showing dielectric qualities and temperature coefficients of tubular and disc resistors is described on new 2-page Plastic Card. —Electronics Div., Erie Resistor Corp., Erie, Pa.

Circle **511** on inquiry card.

OSCILLATOR CONTROL, resonant reed type, is described in 11-page Bulletin 34-28.—James G. Biddle Co., 1316 Arch St., Phila. 7, Pa.

Circle **512** on inquiry card.

ELECTRONIC EQUIPMENT, including amplifiers, capacitors, potentiometers, power supplies, switches, transceivers, etc. are catalogued in recent 16-page copy of "This Month."—Herbach & Rademan, 1204 Arch St., Phila. 7, Pa.

Circle **513** on inquiry card.

PRINTED CIRCUITRY on plastics, including information about the materials and method used, are detailed in new 6-page bulletin.—Synthane Corp., Oaks, Pa.

Circle **514** on inquiry card.

ELECTROLYTIC CAPACITORS, designed for long life, but interchangeable with commercial units are described in new 12-page Catalog 1165. —Industrial Condenser Corp., 3243 N. California Ave., Chicago 18, Ill.

Circle **515** on inquiry card.

MULTI-HEADERS and plugs, hermetically sealed, octal-type and standard patterns, are subject of 16-page Catalog 657A.—Hermetic Seal Corp., 29 S. 6th St., Newark 7, N. J.

Circle **516** on inquiry card.

ELECTRONIC COMPONENTS. New 48-page Catalog 571 describes and illustrates maker's audio transformers, discriminators, high-Q reactors, magnetic amplifiers, power components, pulse transformers, and ultrasonic components.—Freed Transformer Co., Inc., 1718-1736 Weirfield St., Brooklyn (Ridgewood) 27, New York.

Circle **517** on inquiry card.

COIL BOBBINS of one-piece molded nylon are covered in new 2-page data sheet.—Gries Reproducer Corp., 400 Beechwood Ave., New Rochelle, N. Y.

Circle **518** on inquiry card.

ELECTRONIC SHEET METAL fabrications are described in new 20-page Catalog 357.—Chassis Co., Lynwood, Calif.

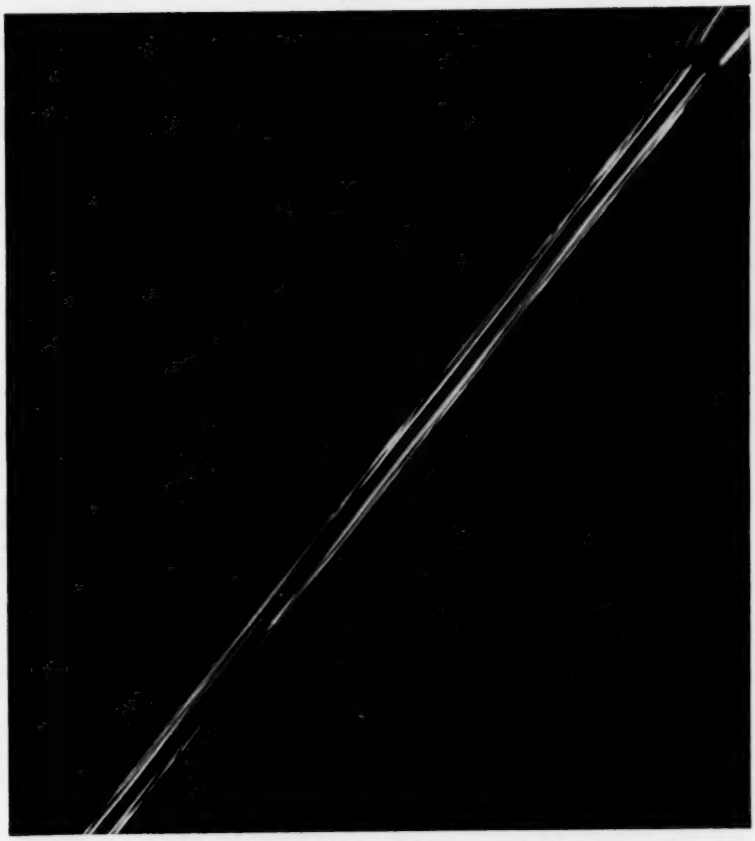
Circle **519** on inquiry card.

ELECTRONIC COMPONENTS, including relays, stepping switches, steppers, solenoids, choppers, capacitors, etc., are listed in new 8-page catalog.—Universal Relay Corp., 42 White St., New York 13, N. Y.

Circle **520** on inquiry card.

FUSE, consisting of "grasshopper" type combined with heat coil and overload failure warning relay, is described in new 4-page "Newsletter" 5-57.—Cook Electric Co., 2700 N. Southport Ave., Chicago 14, Ill.

Circle **521** on inquiry card.



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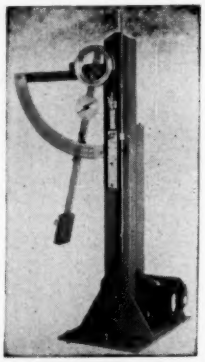

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A' G' A' Division of Elastic Stop Nut Corp. of America 1381
American Chain & Cable Co., Inc.—Helicoid Gage Division 1339
American Machine and Metals, Inc. 1235
American Meter Company 1246
American Time Products, Inc. 1349
Amperite Co., Inc. 1228
Ampex Corporation 1227
Amthor Testing Instrument Co., Inc. 1394
Analogue Controls, Inc. 1361
Annin Company 1362
Applied Science Corp. of Princeton 1364, 1392
Arnoux Corporation 1267
Assembly Products Inc. 1377
Automatic Electric Sales Corporation 1383
Automatic Temperature Control Co., Inc. 1370

Bacharach Industrial Instrument Co. 1374
Bailey Meter Company 1373
Baldwin-Lima-Hamilton Corporation 1238
Barber-Colman Company 1253
Barber-Colman Company, Wheelco Instruments Div. 1254-1255
Bendix Aviation Corp. 1286
B-I-F Industries, Inc. 1371
Black, Sivalls & Bryson, Inc. 1269
Borg Corporation, George W. 1336, 1337
Breeze Corporations, Inc. 1252
Briggs Filtration Co. 1377
Bristol Company 1249, 1274, 1351
Brown Instruments Division of Minneapolis-Honeywell Regulator Co. 1306, 1307, 1308, 1309, 1310, 1311
Bryant Chucking Grinder Co. 1271
Builders-Providence, Inc. 1371

Cannon Electric Co. 1284
Century Electronics & Instruments, Inc. 1329
Clare & Co., C. P. 1275
Cohn Corp., Sigmund 1390
Comar Electric Company 1352
Computer Div., Bendix 1286
Consolidated Electrodynamics Corporation 1248, 1260, 1279
Consolidated Resistance Company of America, Inc. 1392
Cosa Corporation 1380
Crucible Steel Company of America 1231

Daystrom Systems, Division of Daystrom, Inc. 1323
Decker Aviation Corporation 1333
Dialight Corporation 1357
Diehl Manufacturing Company 1234
Du Mont Laboratories, Inc., Allen B. 1262
Dwyer Mfg. Co., F. W. 1379
Dynamic Instrument Company Inc. 1340

Eagle Signal Corporation 1230
Edison Industries, Inc., Thomas A., Instruments Division 1360
Electric Auto-Lite Company 1388
ElectroData—Division of Burroughs Corporation 1223
Electronic Associates, Inc. 1316
Engineered Electronics Company 1354
Eppley Laboratory, Inc. 1261
Esterline-Angus Company, Inc. 1388

Falstrom Company 1220
Fenwal Incorporated 1268
Fischer & Porter Co. ..... Inside Back Cover
Fisher Governor Company 1264
Foxboro Company 1272-1273, 1280-1281
Franklin Electronics, Inc. 1384
Fulton Sylphon Division 1277

Gaertner Scientific Corporation 1348
General Controls Co. 1270
General Electric Company 1287
General Motors Corporation 1259
Green Instrument Company 1379
Gubelman Publishing Company 1378

Hagan Chemicals & Controls, Inc. 1258
Hammel-Dahl Company ..... Back Cover
Haydon Company, A. W. 1371
Hays Corporation 1225
Heiland Instruments 1355
Heise Bourdon Tube Company, Inc. 1386
Helicoid Gage Division—American Chain & Cable Co., Inc. 1339
Hoke Incorporated 1263
Hughes Aircraft Company 1251

Illinois Testing Laboratories, Inc. 1380
Imperial Brass Mfg. Co. 1263
Industrial Test Equipment Co. 1368
International Business Machines Corporation 1298

Johnson Engineering Company, Inc., Welton V. 1350
Jones Optical Works, A. D. 1378
Joy Manufacturing Company 1250

Kato Engineering Company 1364
Kearfott Company, Inc. 1363
King Engineering Corp. 1336

Leeds & Northrup Company 1282
Lepel High Frequency Laboratories, Inc. 1365
Lewis Engineering Co. 1236
Librascope, Inc. 1219
Lockheed Aircraft Corporation 1353
Lynn, Robert M. 1348

Mack Electric Devices, Inc. 1392
Magnatrol Valve Corp. 1374
Mallory & Co., Inc., P. R. 1359
Manning, Maxwell & Moore, Inc. 1242-1243, 1276
Marsh Instrument Co. 1380
Marshalltown Manufacturing Co. 1378
McLean Engineering Labs. 1362
Measurements Corporation 1337
Meriam Instrument Company 1344, 1367
Midwestern Instruments Inside Front Cover, 1232-1233
Mine Safety Appliances Company 1240-1241
Minneapolis-Honeywell Regulator Co., Industrial Division 1306, 1307, 1308, 1309, 1310, 1311
Missile Development Division, North American Aviation, Inc. 1347
Moeller Instrument Company 1256

Nash Engineering Company 1342
New Hermes Engraving Machine Corp. 1381
Newmark Ltd., Louis 1392
Niagara Blower Company 1222
North American Instruments, Inc. 1387
Norwood Controls 1257

Offner Electronics Inc. 1356
Optical Coating Laboratory, Inc. 1377

Palmer Thermometers, Inc. 1338
Panellit, Inc. 1385
Permag Corp. 1354
Petrometer Corporation 1375
Philadelphia Thermometer Co. 1376
Philbrick Researches, Inc., George A. 1266
Pittsburgh Consolidation Coal Company 1350
Plummer & Kershaw 1375
Precision Thermometer & Instrument Co. 1379
Premier Metal Products Co. 1366
Pyrometer Instrument Co., Inc. 1337

Rawson Electrical Instrument Company 1387
Rex Rheostat Co. 1392
Richardson Camera Company 1345
Robbins Aviation 1253
Royal McBee Corporation 1226
Royson Engineering 1392
Rubicon Company 1357

Sanders Associates Incorporated 1358
Schaevitz Engineering 1375
Sensitive Research Instrument Corporation 1220
Servonic Instruments, Inc. 1381
Shore Instrument & Mfg. Co., Inc. 1336
Slaughter Company 1392
Smith Co., S. Morgan 1393
Sorensen & Company, Inc. 1245
Statham Development Corporation 1387
Statham Laboratories 1343
Superior Tube Company 1278
Swartwout Company 1335
Synchro-Start Products, Inc. 1374

Technical Charts Incorporated 1391
Technique Associates 1376
Texas Instruments Incorporated 1344, 1346
Thermo Electric Co., Inc. 1368
Tiffen Marketing Co. 1390

Uehling Instrument Co. 1346
Unertl Optical Co., John 1394
United Electric Controls Company 1328
United States Gauge, Div. of American Machine and Metals, Inc. 1235

Varian Associates 1229
Veeder-Root Incorporated 1341
Victoreen Instrument Co. 1389

Wallace & Tiernan Incorporated 1369
Weckesser Company 1390
Welch Scientific Company, W. M. 1331
West Coast Electrical Mfg. Corp. 1366
Weston Electrical Instrument Corporation, a Subsidiary of Daystrom, Incorporated 1224
Wheelco Instruments Div., Barber-Colman Company 1254-1255
Wilmad Glass Company, Inc. 1376

NEW LITERATURE

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MINIATURE COAXIAL CABLES and connectors, including specifications, applications, nomenclature, etc. are covered in new 32-page Brochure 20M-3-57.—Microdot, Inc., 220 Pasadena Ave., South Pasadena, Calif.

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ELECTRICAL CONNECTORS for use in aircraft, radio, industrial instruments, and general electrical equipment are discussed in new 64-page Catalog K6. Battery and power connectors are subject of 32-page Catalog GB6.—Cannon Electric Co., 3209 Humboldt St., Los Angeles 31, Calif.

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ELECTRICAL CONNECTIONS, including compression terminals, compression tooling, panels, terminal blocks, and sheath connectors for shielded and coax cable, are the subject of new 8-page brochure "What Goes On Here?"—Burndy Corp., Norwalk, Conn.

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BREADBOARD PARTS, for easy assembly of complicated gear trains and servomechanisms are described in new 24-page Catalog 575.—Beckman/Helipot Corp., Newport Beach, Calif.

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MICRO-BALL BEARINGS are the subject of new 4-page Bulletin 19.—New Hampshire Ball Bearings, Inc., Peterborough, N. H.

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ROLLER GEAR DRIVES, "E" series, for high-speed precision indexing are the subject of 4-page Bulletin 107A.—Ferguson Machine Corp. of Indiana, Box 5841, St. Louis 21, Mo.

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EYELET PARTS, deep drawn from ferrous and non-ferrous metals, are discussed in new 14-page Bulletin.—Sylvania Electric Products, Inc., Parts Div., Warren, Pa.

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FABRICATION

METAL FABRICATION facilities, staff, industries served, and materials used are presented in 8-page portfolio, "Falstrom Illustrated."—Falstrom Co., 201 Falstrom Court, Passaic, N. J.

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BRAZING of stainless steel is the subject of new 8-page Bulletin GER-1331.—General Electric Co., Schenectady 5, N. Y.

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AUTOMATIC WELDING equipment, including illustrations of maker's "Fillerare" automatic welding equipment for consumable-electrode gas-shielded welding, is covered in new 4-page Bulletin GEC-1334B.—General Electric Co., Schenectady 5, N. Y.

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MACHINING OF TEFLON, New 4-page reprint (DuPont Magazine) presents solutions for electrical insulation, anti-corrosion and mechanical problems which require precision machined Teflon.—Tri-Point Plastics, Inc., 175-177 I. V. Willets Road, Albertson, L. I., N. Y.

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3	22	41	60	79	98	117	136	155	174	193	212	231	250	269	288	307	326	345
4	23	42	61	80	99	118	137	156	175	194	213	232	251	270	289	308	327	346
5	24	43	62	81	100	119	138	157	176	195	214	233	252	271	290	309	328	347
6	25	44	63	82	101	120	139	158	177	196	215	234	253	272	291	310	329	348
7	26	45	64	83	102	121	140	159	178	197	216	235	254	273	292	311	330	349
8	27	46	65	84	103	122	141	160	179	198	217	236	255	274	293	312	331	350
9	28	47	66	85	104	123	142	161	180	199	218	237	256	275	294	313	332	351
10	29	48	67	86	105	124	143	162	181	200	219	238	257	276	295	314	333	352
11	30	49	68	87	106	125	144	163	182	201	220	239	258	277	296	315	334	353
12	31	50	69	88	107	126	145	164	183	202	221	240	259	278	297	316	335	354
13	32	51	70	89	108	127	146	165	184	203	222	241	260	279	298	317	336	355
14	33	52	71	90	109	128	147	166	185	204	223	242	261	280	299	318	337	356
15	34	53	72	91	110	129	148	167	186	205	224	243	262	281	300	319	338	357
16	35	54	73	92	111	130	149	168	187	206	225	244	263	282	301	320	339	358
17	36	55	74	93	112	131	150	169	188	207	226	245	264	283	302	321	340	359
18	37	56	75	94	113	132	151	170	189	208	227	246	265	284	303	322	341	360
19	38	57	76	95	114	133	152	171	190	209	228	247	266	285	304	323	342	361

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ELECTRIC ERASING MACHINE. "Sovereign," for engineer and draftsman is detailed in new 2-page data sheet.—Frederick Post Co., 3650 N. Avondale Ave., Chicago 18, Ill.

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ULTRASONIC TRANSDUCERS are described in two new 2-page bulletins: (1) the welded "B series," in 2-page Bulletin S-502, (2) the "E series," which is completely immersible in the cleaning fluid, in Bulletin S-503.—Branson Ultrasonic Corp., 40 Brown House Rd., Stamford, Conn.

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TRACING PAPER. New 4-page Catalog A-2299 describes maker's resin-transparentized tracing paper.—Charles Bruning Co., Inc., 4700 Montrose Ave., Chicago 41, Ill.

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TACHOMETERS. New 12-page folder describes maker's line of tachometers, hourmasters, milemasters, adapters, clutches, and flexhole shafts for industrial, automotive, aeronautical and marine application.—Barbour Stockwell Co., Cambridge 39, Mass.

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STEEL RESEARCH. New 32-page booklet, "Research with Crucible," outlines company's research activities and illustrates many specific projects and equipment.—Crucible Steel Co. of America, P. O. Box 1558, Pittsburgh 30, Pa.

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LUBRICATORS. New 2-page Bulletin BL-150 illustrates and describes design and operation of semi-automatic spring discharge piston pump lubricators.—Bijur Lubricating Corp., Rochelle Park, N. J.

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SOLDERING STAND. New 2-page Bulletin 443 describes Model SS 10 Soldering Stand.—Ess Specialty Corp., 96 South Washington Ave., Bergenfield, N. J.

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PROJECTION SYSTEM. New 4-page Bulletin discusses GPL's new closed circuit television projection system model PB-611A.—General Precision Lab., Inc., Pleasantville, New York.

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POWER SUPPLIES

REGULATED POWER SUPPLY, transistorized, with dual range, including operating characteristics, and specification data on model 50TM/10, is described in new 10-page bulletin.—Electronic Research Associates, Inc., 67 E. Centre St., Nutley 10, N. Y.

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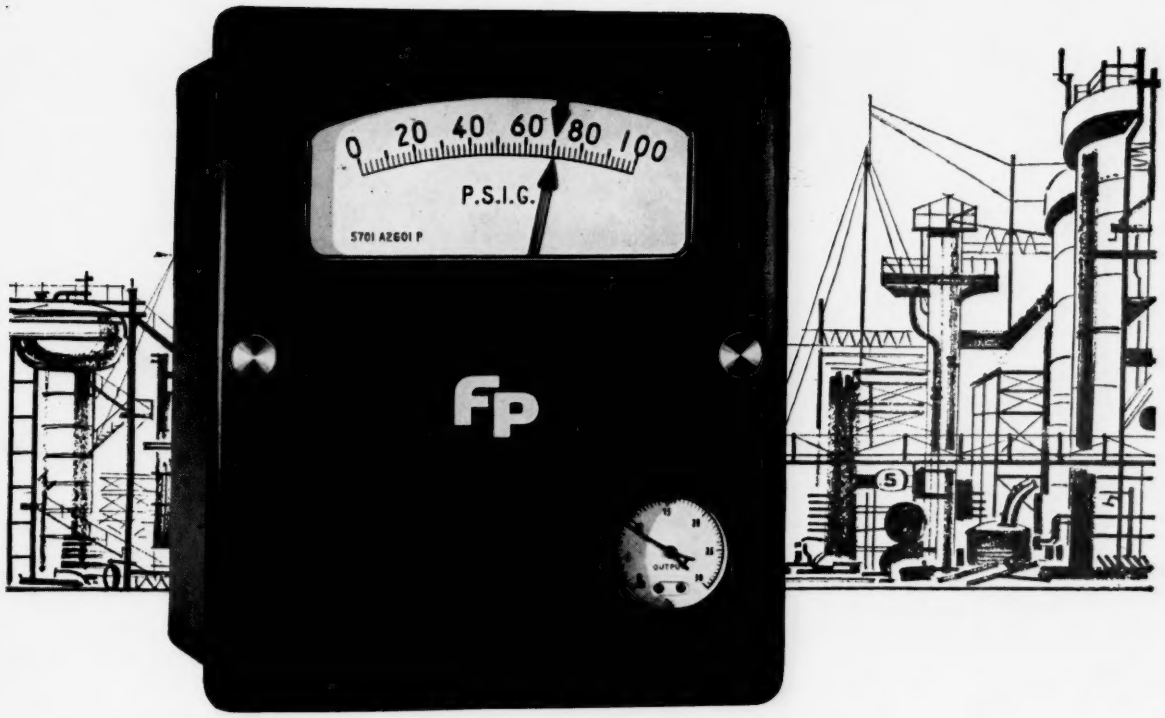

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